METALLURGIA

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EMERGING—— WITH RENEWED VIGOUR

By W. J. Brooke.

British iron and steel industries are emerging from the world depression in advance of other countries, and the improvement shows every sign of continuing. In allegorical form, Mr. Brooke describes our mistakes of the past and the efforts now being made to restore these industries.

"We had a kettle; we let it leak;
Our not repairing it made it worse,
We haven't had any tea for a week,
The bottom is out of the universe."

Photo by courtesy of Dorman Long & Co., Ltd.
Running-off molten iron from the blast-furnace for transfer in ladles to the steel plant.

WAS it during a moment of prophetic vision, seeing in his mind's eye the British iron and steel industry of the early '30s, that Kipling years ago wrote this?

For some time now the bottom has indeed seemed out of our universe; we have seen outputs growing smaller, our order books more and more depleted, margins of profit getting less and less, and, finally, vanishing, and ourselves plunged into the apathy of despair.

We have naturally looked round for a scapegoat, and have been content to fasten the blame on our Continental competitors, who, aided by cheap labour, and new plants provided for them by post-war treaties at little or no cost to themselves, have been able to cut us out of the markets which we had looked upon for so many years as intrinsically our own.

"We had a kettle"—yes, and up to the later years of the past century it was almost unique, for we were able to provide not only tea for ourselves but for most of the world as well. We made large profits thereby, and became wealthy, so much so that others decided to do likewise, and, starting where we left off, fostered by rapidly growing demands of their own immediate surroundings, and helped by exceedingly bountiful natural resources and labour conditions, were able to supplant to a certain extent our trade in various markets; in fact, our kettle began to leak.

"We let it leak," since notwithstanding the loss of trade in some directions, owing to the rapid growth of world developments, very often in our own Colonies, we could still keep our plants running at a profit, even though we did not maintain our proportion of the world's increasing business, and from being first rapidly fell to second, third, and even fourth place in the world queue.

Other nations, however, realising the rapidly growing world demand for iron and steel, set themselves out to supply it, and at the same time took steps definitely to increase the demand until, in 1929, the world production and consumption of iron and steel had reached the enormous total of 118 million tons, as compared with 11 million tons in 1889; Great Britain having come down to fourth place from first.

To a certain extent the enormous increase in production, chiefly in America, France, and Germany, brought with it its own Nemesis, in that increased production had outstripped increased consumption, and as this state of affairs was happening in many other commodities, it was natural that sooner or later supersaturation would occur, with the inevitable slump. In a great measure this enormously bloated production was brought about by the idea (now seen to be fallacious) that the lower the price the product could be made for, the more units of production would be sold, and, consequently, plants with enormous outputs were devised, which, to a large extent, relied for the cheapening of cost of production upon the large divisor or big weekly throughput.

Lately it has seemed in this country that "the bottom is out of the universe," and many minds have been concerned with the problem of mending the leak in our kettle; first of all so that we might be able to provide ourselves with tea, and, later on, perhaps our neighbours as well.

Having got tariffs, we hope these will keep out foreign

iron and steel from our own home markets, and thus enable us again to work our plants in full production. We find, however, in some instances, that the leak in the kettle is still unmended, and the problem is to devise the best and cheapest manner to effect the repair.

Obviously it is useless to try making a new kettle of a larger size—already the world has found to its cost that quantity *per se* no longer counts as an asset.

It would therefore appear that we must approach the subject of the reorganisation of the industry in other ways.

Of late the terms "reorganisation" and "rationalisation" have been used *ad nauseam*, and often indiscriminately and without reference to their meaning. Rationalisation was first talked of in Germany, and then was intended to mean reorganisation, in which *rationing* of both production and distribution was made a predominant factor.

Already there are signs that there exists a certain amount of confusion of thought when discussing the best methods of improving the industry, and of bringing some sort of order out of chaos; but the necessity for action is urgent, owing to the conditions under which protection of the home markets by tariffs has been accorded. It is to be feared that unless great care is exercised steps may be taken in haste that may be repented when too late at leisure, and that the terrible mistakes made during the stress and hurry of the war be again repeated.

Without in any way belittling their efforts and achievements in the past, it may be necessary to curb the activities of the engineers in the future, and to call more and more upon the services of the metallurgist, chemist, and physicist. There undoubtedly remains a great deal that can be done in the way of reduction of productive costs that can be effected without increasing output at all, and in this respect one can count on the technology of fuel economy in its various aspects as being one of the chief means whereby that end may be achieved.

After having taught the world mass production, without providing the corollary of mass consumption, the Americans have in the depths of their despair begun to think that they have created something of a "Frankenstein" monster, and have invented a new doctrine which, with the enthusiasm whereby they always welcome something new, they have inflicted with the awful name of "technocracy," a name nearly as nauseous as a bad smell.

We can, I think, imitate our American cousins in an attempt to get away from the evils of mass production and by keeping cool heads, thinking on level terms, and just carrying on in a commonsense manner, do a great deal in the direction of economic production.

We have in our industry many blast-furnace plants which are quite reasonably up to date, or at any rate can be made so by comparatively small expenditure of capital. The lines upon which these improvements can be made are well known, and one can say are almost standardised; and there is not the slightest need to attempt anything of so gigantic a character as the Ford experiment at Dagenham in order to make cheap pig iron.

We can certainly do a lot by paying attention to the preparation of the materials constituting the blast-furnace burden. Screening out of the fines, and reduction of lumps to a uniform maximum has already in some districts proved of enormous value—the extent of the value realised varying, of course, with the natural characteristics of the ores. The fines can be used under control, either raw, or calcined, and sintered. Sintering undoubtedly has a great future before it, but much experimental work remains to be done before one can say with certainty what degree of economy can be effected in the case of such very lean ores as occur in Frodingham and Scunthorpe, and perhaps Northamptonshire. With rich ores containing 50% and upwards of iron there is no doubt that sintering is a paying proposition, especially when such cheap by-products as flue dust, pyrites, residues, etc., are mixed with the fine ore to be treated.

Much work has also been done during the past few years by the Midland, Northern, and Scottish Blast-furnace Coke Research Committees. New light has been thrown on the manufacture of blast-furnace coke, and we know now what types of coke are of the most economic value to the blast-furnaces.

Coupled with the proper treatment of the ore, we need the right kind of coke and the right size, screened entirely free from fine dust, and such particles of coke as are liable to create dust in the passage through the blast-furnaces.

The modern coke oven, employing high temperatures for carbonising, is already proving itself capable of producing a type of coke more suitable for the blast-furnace than has been possible by means of the older designs. This is also all the more welcome as much of the better-class coking coals are showing signs of gradual depletion. With high-temperature coking it is possible to make quite good coke from coals that heretofore have been of only medium value.

No matter how well coke may be made and screened at the ovens, it still remains of a more or less friable nature, and transit by railway, with subsequent handling, can never improve its value for the furnace.

This, then, constitutes one reason for a coke-oven plant being located in proximity to the blast-furnace, and if one has steelworks in addition, and full use can be made of the surplus rich gas, very considerable economies can be effected. In this case not only can the coke be well screened at the ovens, but it can be delivered in this manner with a minimum of handling straight from the ovens to the furnaces.

In cases where this has been done a saving of quite 3% is shown, due to this fact alone, and when one takes into account the value of ore preparation, and improved and regular quality of coke, from 10% to 12% improvement in fuel efficiency is quite possible.

The replacement of producer coal at the steel furnaces by a mixture of gases from the blast-furnaces and ovens further liberates a fund which can be used for the credit of the coke and pig-iron production, thereby tending to the cheapening of the production of both. If the blast-furnaces are unable owing to the quality of ore used to supply sufficient gas for the mixture, then the steel furnaces can be designed to employ oven gas alone. In this case the coke ovens will obtain the whole of the value of replaced coal as a credit, and the blast-furnaces then gain by obtaining a correspondingly cheaper coke.

Apart from gas credits, the modern oven makes most of the ordinary by-products by extracting and collecting the maximum of tar, sulphate of ammonia, and crude benzole. The labour costs are reduced to a minimum, and, if well constructed, repairs and maintenance will be very low. All this means cheap coke, which, with the other advantages above referred to, tend to very considerably reduce the pig-iron cost.

This again can be reflected in the steel-ingot cost, but there are other advantages.

To gain the best results when using gas, steps *must* be taken to provide uniform pressure at all parts of the consuming system. Various methods have been tried by means of pressure controllers of different kinds, but the only really effective one is obtained by means of gasholders of a size large enough to tide over short interruptions to supply and connected in parallel with the system, preferably in as central a position as possible to minimise wire drawing.

Having this uniformity one is able to control the consumption of gas by means of meters, preferably recording as well as indicating.

Waste heat, further, must be harnessed, and much valuable power can be derived from the steel-furnaces, gas-engine exhaust, and possibly soaking-pits and other forms of reheating furnaces.

Systems such as here outlined possess illimitable chances of scientific economy; all the heat is under absolute

control, and indications have already been observed that lead one to believe that we are only now at the beginning of realising true heat conservation with its startling effect upon costs and efficiency generally.

It can easily be seen that systems such as above described do not of necessity cause increase of the units of production, though some effect in this direction may be realised.

The chief of the advantages to be obtained are greater scientific control, a better and more uniform product at its various stages of manufacture, considerable reduction of cost, and this without relying in any way upon an increased output to provide the larger divisor.

I have only touched upon the subject in a very sketchy manner, and merely instanced it as one of the means whereby our industry can endeavour to raise itself out of its present depressed state into one of greater prosperity.

In closing, and reverting to my text, it is true that in the past we allowed our kettle to leak. Through "laissez faire" supineness, or merely because we were too well off, we neglected to repair the leak. When through lack of tea we realised that the leak must be stopped we found ourselves by reason of depression, over-taxation, and unfair competition in the position of not having the wherewithal to effect the repair. We were somewhat inclined to blame providence, our competitors—anything rather than our own lack of foresight. Stress of circumstances has definitely opened our eyes to the position in which we find ourselves, and we are now determined to put forward every effort to make up for the mistakes of the past.

I do not believe that in our trade we have any reason to suffer from an inferiority complex; we are already, as shown by the output of ingots in 1932, emerging from the world depression in advance of other countries, and the improvement shows every sign of continuing. As usual, the Briton is never so formidable as when he is fighting with his back to the wall, and provided we employ our usual levelheadedness, do not rush into unnecessary and gigantic experiments merely because someone else has done so, and, above all, explore every possible avenue to cheapen costs *without increasing production*, I am convinced that we shall yet find good employment for most of our unemployed workers. We have a great heritage in a reputation for quality, and we should endeavour still further to increase our renown as manufacturers of the highest quality products. By adopting some such methods we may, and probably will, regain much of our lost prestige as steel and iron producers, and I trust provide some much-belated dividends to our long-suffering shareholders.

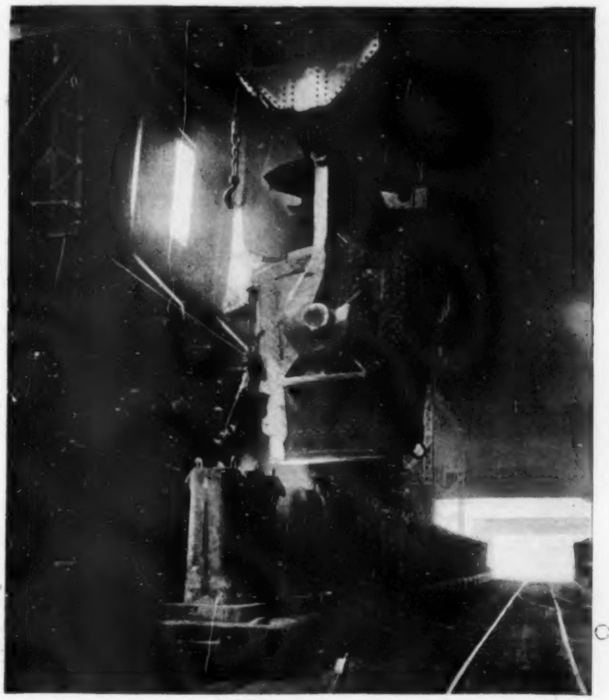

Photo by courtesy of Dorman Long & Co., Ltd.

Filling moulds for steel ingots.

Cutting Steel with Oxygen Machines

By C. G. Bainbridge, A.M.I.Mech.E.

The effect of oxygen cutting on various types of steel is discussed, and the results of various mechanical tests on oxygen-cut specimens are given. Many of the data are taken from a recent paper by the author before the Institution of Welding Engineers.

Effect of Oxygen Cutting on Material.

ALL mild steels containing up to 0·3% carbon can be quite easily cut, and the surface of the cut will be readily machinable after cutting. The general effect of oxygen cutting is to change the normal ferrite and pearlite condition to sorbitic pearlite with ferrite envelopes at the cut edge; this results in a slight toughening at the cut surface, the total increase in Brinell hardness on mild steel being only 30 to 40 points. There is also an increase of carbon near the surface of the cut, but this carbon change usually only penetrates inwards for about half the total depth of effect.

This is a structural effect similar to that produced by water-quenching and tempering steel of the same composition, and is largely due to the chilling effect of the comparatively cold mass of metal at the back of the cut surface. Cuts made on metal which has been preheated show only a superficial film of toughened metal. On ordinary mild steels of 20 to 30 tons tensile, 0·18 to 0·25 carbon, the maximum depth of change of structure extends inwards from the cut surface for not more than $\frac{1}{8}$ in., and generally only for $\frac{1}{16}$ in. or $\frac{1}{32}$ in. This applies to material up to 3 in. or 4 in. thick, but the depth of effect varies with the material thickness, and may be nearly $\frac{1}{4}$ in. on material 6 in. thick. This is the maximum depth of effect, at which point the steels become normal in structure and hardness. It will be seen that oxygen cutting has no detrimental effect on the material, provided it is a steel not adversely affected by the application of heat.

If the article is normalised after cutting all traces of cutting effect will be removed, but unless the use of the article makes machining necessary jobs cut from steel containing up to 0·3% carbon can be put into service exactly as produced. It is recommended that steel containing 0·3% to 0·4% carbon be preheated to about 500° C. (visible red in daylight) before cutting.

Alloy steels, such as nickel, nickel-chrome, nickel-chrome-molybdenum, and all similar steels, should be preheated before cutting to avoid hardness of the cut faces and internal stresses which may lead to cracking. Great advantages can be obtained by employing oxygen for cutting manganese steel. Oxygen cutting has no detrimental effect,

and perfectly smooth and accurate cuts are obtainable, with no hardening of the cut surface.

Some mechanical tests carried out on oxygen-cut samples gave interesting results.

Tensile Tests.

Fourteen tests, carried out to ascertain the effect of oxygen cutting on the tensile strength of mild steel, gave the following average results.

Oxygen Cutting.	Machine Tool Shaping.
Yield 7/50 tons per sq. in.	16·50 tons per sq. in.
Tensile strength, 24·95 tons per sq. in.	24·40 tons per sq. in.
Elongation, 21·95% in 8 in.	23·2% in 8 in.
Reduction of area, 59%.	58·8%.

Bend Tests.

The ductility is not affected to any great extent, while the yield point and tensile strength are slightly increased, this is probably due to the slight toughening action of the cutting on the surface of the metal. In order to investigate further the effects of oxygen cutting on the ductility of the material, some bend tests were made in the following manner: A piece of mild steel, 2 in. thick, was cut into a strip about ⅝ in. wide, with oxygen cuts on both sides of the strip; the strip was then bent round a ⅞-in. diameter pin, so that the cut surfaces were in tension and compression respectively. No signs of cracking occurred until the piece had been bent through almost 180°.

It should not be overlooked that oxygen cutting depends on the accurate direction of a jet of gas through the depth of the metal, and that characteristically this jet will tend to take the path of least resistance. Cavities and porous spots, laminations, or slag inclusions will, therefore, almost certainly cause defects in the cutting due to diversion of the oxygen stream; only good quality steel should be used, and forgings should be free from any of the above defects. Firms producing large forgings, and who have installed an oxygen cutting machine, now find it convenient in many cases to eliminate expensive intricate forgings, which cannot be conveniently or accurately done under the hammer, leaving the intricate shaping to be done by the oxygen cutting machines.

British Standard Izod Tests on Steel Crankshaft Forging.

Analysis—	Silicon	0·187%
	Sulphur	0·024%
	Phosphorus	0·029%
	Manganese	0·780%
	Carbon	0·400%

This shaft had circular web sections, and was gapped out in the usual manner by oxygen cutting machine.

The following tests were carried out on pieces with and without cutting effect present:—

"A" specimens from mass of steel, right away from cutting.

"B" specimens, with notches in untouched cut face.

All above specimens were tested transversely, the blow of the Izod machine hammer being parallel to the grain of the steel.

Results in Foot-pounds.

"A."	"B."
9·0	22·0
7·0	18·0
11·5	18·0
14·0	18·0
Average = 10·375	Average = 19·0

Note.—Although putting the notch in the cut-face removed most of the metal altered by the oxygen cutting process, a small layer of this material still remained and was seen in the fracture, being "silky" in appearance. It is claimed that the "Sorbitic" (toughened) structure of this layer resulted in the increased Izod figures for "B" specimens.

"C" specimens from mass of steel right away from oxygen cutting.

"D" specimens, with notches at back of untouched cut face.

These specimens ("C" and "D") were tested transversely, the blow of the Izod machine hammer being endwise to the grain of the steel.

Result in Foot-pounds.

"C."	"D."
10·0	17·0
14·0	19·5
15·0	20·0
16·0	22·0
Average 13·75	Average 19·6

Note.—It is claimed that the "Sorbitic" (toughened) structure of the material altered by the oxygen cutting process gave rise to the increased Izod values for "D" specimens.

It is not suggested that the impact figures are high or all that was to be desired, but it was desired to compare the effects of the alteration in structure by the oxygen cutting process on the shock resistance of the steel as evidenced by Izod impact tests. The steel forging was in a normalised condition, and these tests certainly show that the toughened oxygen-cut material gave rise to an increased Izod impact figure.

At first thought one might ask why an increased Izod impact value is obtained when it is already known that oxygen cutting results in increased Brinell hardness, yield point, and tensile strength, seeing that in ordinary normalised carbon steels the Izod figure varies inversely with the Brinell hardness and tensile strength. The writer suggests the following as an explanatory answer to such a question:—

Whilst one would expect impact values to vary inversely with Brinell hardness and tensile strength in ordinary carbon steels in the normalised or annealed condition, this more or less acknowledged fact does not apply to hardened and tempered (toughened) steels. The writer implies that a carbon steel hardened and tempered will give a greater impact value than the same steel in the normalised condition, even although in the hardened and tempered state the Brinell hardness and tensile strength are greater. This exception to the general rule comes about through the particular tough structure produced by hardening and tempering, the particular structure being referred to in metallographic terms as "Sorbitic."

It so happens that the average cooling rate of steel during the oxygen cutting process generally results in the formation of this tough "Sorbitic" structure, so that the material at the oxygen-cut face, and for a small depth inwards, has a structure approximating to that of hardened and tempered steel. It is well known that the "Sorbitic" condition is the toughest condition in steel, and the condition giving the highest shock-resisting properties, so the writer feels justified in being of the opinion that the reasonings adopted in attempting to explain the increase in Izod impact values noted for specimens "B" and "D" are correct.

Effect of Cold-Rolling on the Age-Hardening of Duralumin.

Data on the effect of cold rolling on the strength properties of the specified duralumin alloy 681 B are given by K. L. Meissner in *Zeitschrift für Metallkunde*, 1932, pages 88–89. Plates 2 mm. thick were rolled immediately after quenching or after storing for five days. The degree of rolling was 2, 5, 10, 15, 20, 30, 40, and 50%. Tensile strength, stretch limit, and elongation were determined; the results are shown in two diagrams. Tensile strength and stretch limit are lower when the alloy is rolled immediately after quenching, the difference increasing with increasing degree of rolling. The elongation figures showed only slight differences. In a further series of experiments it was found that cold rolling does not affect the strength if performed about six hours after quenching or later. With a rolling degree of 2%, however, the strength figures continued to increase with increasing storing time (over 6 hours). The elongation figures showed irregularities.

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THE BRITISH INDUSTRIES FAIR AND PROGRESS

IT has been said on more than one occasion that the British Industries Fair is an expensive luxury which industry can ill afford at a time of depression. Some have suggested that money is difficult enough to get for plant reconstruction and other developments without spending it on display. This point of view would be acceptable if the industrial supremacy of this country had remained as it was years ago. Then our supremacy was so great that overseas buyers had little choice. Much change has taken place since those days; other countries have developed industrially, and competition for overseas trade is so keen that manufacturers can no longer wait for orders to come to them—they must seek them. For this reason the point of view indicates a short-sighted policy. That it is not the general opinion will be understood when it is realised that the exhibits at the forthcoming Fair not only occupy a greater area than any former Exhibition of its kind, but are increased both in number and variety.

It will be appreciated that development in plant and equipment or in the technique employed in manufacture is primarily concerned with improving either the quality of the product, the quantity produced in a given time, more economical production, or a combination of these improvements. But unless corresponding development is made in the distribution of these products the development is incomplete. The British Industries Fair provides one method of developing sales of British manufactures. It is organised by the Department of Overseas Trade with the object of bringing together potential buyers and manufacturers with a view to effecting sales. The increasing desire of manufacturers to exhibit their specialities at the Fair, even in these lean times, is a clear indication that valuable business results. In many instances contacts have been made at former Exhibitions that have resulted in new business months afterwards, and the orders have been of such a character that they would not otherwise have been placed with the firm finally decided upon.

The British Industries Fair differs from the majority of other exhibitions of this type in that it is entirely concerned with British potentialities in the industrial field. The international exhibition, like that held at Leipzig, has many advantages, since it offers the potential buyer opportunities of making comparisons in quality and cost of similar products exhibited, but the products and manufactures of the British Empire are so many and varied in character that it is considered necessary to exhibit only British products, and the results are a sufficient justification for continuing to hold this Exhibition. It should not be assumed, however, that the insular position adopted affects competition in any way to the detriment of the buyer, for the very fact that a firm occupies space indicates that strenuous efforts are being made by that firm to exhibit products that are superior to, or are available at a lower cost than, others of a similar type. The tightness of the market makes this competition keener, and no better time could be chosen to buy than now when prices are remarkably low.

In addition to developing business, this annual Exhibition demonstrates the progress of science and arts in the service of mankind and the extent to which the British are contributing. Although a year is a comparatively short interval to show progress, even in comparison with last year's effort, a progressive tendency will be noted by the observant visitor. This is due partly to the spirit of emulation that has been fostered by the Fair, but also to a desire to produce something superior, so that it will form an outstanding exhibit and give the manufacturer a world-wide reputation. Many firms that were formerly in a state of coma have sprung into life, and the new zest has permeated their workpeople in all departments with beneficial results.

On the metallurgical side both ferrous and non-ferrous industries have made commendable improvements that have resulted in higher quality products. Much courage has been shown in the iron and steel industries, for instance, in reorganising and making substantial modifications to existing plant or installing new plant. In many instances blast-furnaces, open-hearth furnaces, and rolling mills have been so modified that their capacity has been considerably increased, and even at the present low prices are able to operate at an economic level. Mention should be made of one particular plant in which blast-furnace and coke-oven gases have been effectively employed to secure economic operation. So accurate a balance has been obtained between the total heat produced and that used in the manufacture of coke, pig iron, and steel, that the only fuel used is the coal charged into the coke ovens. Plant in the non-ferrous metal industries has been modified or scrapped, and new plant installed. New electric mills for dealing with strip 24 in. wide produced in coils weighing nearly half a ton is only one instance.

Although few new alloys will be seen, the increasing application of existing alloys will show development. Considerable success has resulted from the development of high-duty alloys, both ferrous and non-ferrous, and the recent success of the R.A.F. unit in breaking the long-distance record is evidence of progress in the quality of materials to withstand the arduous duties imposed under such exacting conditions. This is of course only one of the honours won for British engineering. Mention might also be made of the Supermarine Rolls-Royce S. 6B seaplane, which won the Schnieder Trophy, the *Blue Bird*, and *Miss England III.*, all of which show the remarkable strides made in developing alloys for special purposes.

It is not possible even to mention the many fields in which substantial developments have been made, but, as we believe the annual Fair has had an influence in promoting the desire for further progress, this "Progress" and "Review" issue will, in a measure, indicate what is behind the exhibits and what efforts are being made to maintain British industries in the forefront of world progress.

While we believe the Exhibition will lead to a considerable amount of business, we cannot hope for the rapid restoration of normal industrial activity. There are many factors operating against a trade revival. Little headway can be made until war debts are settled on a practical basis; even then the path will only be partially cleared for the consideration of other serious impediments to recovery, such as high tariffs, special prohibitive duties, quota schemes, schemes of import licences, and severe restrictions due to money rationing in some countries. While the exhibits at the Fair will definitely show that progress in manufacture and production is not a mirage, the same energy and resourcefulness should be applied to the problems in order to facilitate distribution and thus complete the full development.

The Trend of Progress of Aluminium

By N. F. Budgen, Ph.D., M.Sc.

Developments in the metallurgy of light alloys are reviewed, their application to various industries discussed, and the trend of developments with new alloys is considered.

IT is probably safe to say that progress in the technical development and applications of aluminium and its alloys is still proceeding much more rapidly than that of any other metal or alloy. This was certainly the case some few years ago, but now so much research work has been done that there may perhaps be some little slowing up of revolutionary technical developments. The consumption of aluminium by industry appears, however, to be still on the increase, the present total world absorption having been estimated at about 300,000 tons per annum, which should be compared with the highest pre-war consumption of 70,000 tons.

It is always difficult to state with any exactitude the distribution of consumption of aluminium and its alloys in the various industries, but there is little doubt that the principal fields are in the transport industries, including motor-car parts and bodies, in electrical conductors, cooking utensils, pressure die-castings, and in general sand and die castings employed for a great variety of purposes. An increasing amount of aluminium alloys goes into forgings and hot pressings for various purposes, and the use of aluminium foil is rapidly extending.

Aluminium Electrical Conductors.

For electrical conductors the use of aluminium is increasing rapidly, steel-cored aluminium being generally preferred to aluminium alloy conductors. The development of the alloy conductors has in view the advantage of avoiding the necessity for a steel core, which is objectionable from several points of view, not the least of which is the difficulty of its subsequent removal from the scrap cable before remelting is possible. The fact that the whole of the overhead transmission system in the new British grid is being constructed of aluminium cable in competition with copper is an indication of the progress that has been made in this direction. The amount of aluminium involved in this one job is 8,500 tons. The use of aluminium busbars in power-stations is a development which is no doubt extending.

Aluminium Cooking Utensils.

The popularity of aluminium cooking utensils continues to increase. The bulk of such cooking ware is, of course, pressed or spun from sheet, but increasing amounts of sand- and die-cast ware, which has a longer life, are being employed. For cooking utensils pure aluminium is generally employed; sometimes, however, an alloy with just over 1% of manganese finds favour on account of its somewhat greater stiffness. Die-cast cooking utensils are generally of an alloy containing about 5% of silicon, sometimes with the addition of 2% to 3% of copper.

Aluminium in the Motor Industry.

The motor-car industry continues to absorb a steady heavy tonnage of aluminium in various forms; sheet and sections for bodywork, sand castings and gravity die-castings for the engine, and pressure die-castings for small fittings, carburetters, etc. The amount of aluminium used in private motor-cars is almost directly proportional to the cost of the car—the most expensive cars using the greatest amount of aluminium.

The use of aluminium in motor-cycles does not extend very rapidly, but this will probably come in the future. Experiments recently made show that from a motor-cycle weighing 350 lb. the weight can be reduced by 78 lb. if aluminium is used to the maximum possible extent.

The use of aluminium-alloy pistons continues to increase; in one country alone 7,000 tons of aluminium is used in the production of motor-car pistons. The pistons are generally gravity die-cast, as this method of production gives the strongest castings obtainable. Heat-treated alloys are most often employed, so as to obtain considerable hardness. The tendency of late has been to employ an alloy of the hyper-eutectic silicon type, which has considerably lower coefficient of expansion than the alloys previously generally employed, such as "Y" alloy, S.A.E. 34, and R.R. 53 alloys. With the high-silicon alloys the machining clearances can be cut down practically to those of cast iron, while slap is avoided when the engine is cold, and yet there is no fear of seizure at the running temperature. Various modifications of this type of alloy have been patented in many countries, but all are of approximately the same composition, and contain up to 20% of silicon, with small amounts of copper, manganese, magnesium, iron, and nickel.

Fig. 1.—Aluminium overhead power transmission cable.

In heavy transportation, as in motor-lorries, the use of aluminium crankcases, gearboxes, radiators, etc., has become general; aluminium cylinder heads are used, and, almost always, aluminium pistons. Motor-buses use increasing amounts of aluminium for panelling, seats, seat supports, roofing and window fittings. The use of aluminium in these directions is dictated by the desire to maintain as high a speed as possible, up to the 30-m.p.h. limit, together with the greatest pay load for any given fuel consumption, at the same time keeping within the legal weight limits of 12 tons laden for a four-wheeled vehicle, and 19 tons for a six-wheeler. Vans and tanks for the road transport of meat and milk, which have to be maintained at low temperature by insulation, are now in regular use.

Experiments are being made with tramcars, an experimental car having been constructed for use in Edinburgh which is almost entirely built of aluminium and its alloys. All-aluminium trolley buses have been running in America for some time, and these buses are constructed—even to the underframe—almost entirely of duralumin rolled sections and aluminium sheetings, etc.

Railway Engineering Employs Aluminium.

In railway engineering experiments are being conducted on the use of duralumin coupling rods, which, so far, look very promising. Railway-coach construction, in the case of light, fast railways, has of late embodied considerable amounts of aluminium in the form of panelling, seats, window-frames, sliding doors, and motor gear-cases.

Aeronautics.

In the field of aerial transport the use of aluminium is almost obligatory, and the use of the light metal becomes a first consideration. Even the wing covering on some types of aeroplanes is being made of sheet aluminium in preference to fabric. Two new Zeppelins which are at present under construction are being built almost entirely of duralumin. Fig. 2 shows the Schneider engine, largely made of aluminium alloys.

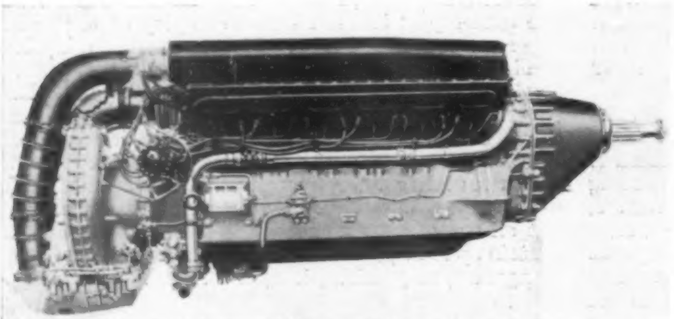


Fig. 2.—Schneider trophy engine, largely built of aluminium alloys (Courtesy of Messrs. Rolls Royce, Ltd.).

Shipbuilding.

In shipbuilding the use of aluminium continues to extend, but its use is sometimes ruled out on account of cost in comparison with cast iron or bronze. Some applications include scuttles, dead-lights, port-lights, oil-fuel transmission, electric-motor casings, stanchions, deck-plates, etc. British submarines are increasingly using large aluminium pistons for their Diesel engines, and most warships use a large tonnage of aluminium in various directions.

Aluminium in Architecture.

In this country the use of aluminium in architecture is nothing like so great as abroad—especially in America; nevertheless there is some tendency on the part of architects to consider its many advantageous features. In America one building alone, which has just been completed, incorporated in its structure 700 tons of aluminium—mostly in the form of cast decorative spandrels, etc. Generally an alloy with about 5% of silicon is employed.

Artistic Finishes on Aluminium and its Alloys.

For interior decoration the use of coloured aluminium has attracted considerable attention. It is now possible to obtain a great variety of very beautifully coloured finishes on either castings or the wrought material. These finishes are mostly produced by aniline dyeing of anodically oxidised coatings. The anodic-oxidised coatings are produced by means of the several processes now available, which include the Bengough process, using chromic acid as a bath; the Alumilite process, which uses sulphuric acid; and the Eloxal process, in which oxalic acid is used. Anodic coatings obtained by these three processes differ somewhat in nature from one another, but consist fundamentally of an extremely adherent coating of aluminium oxide formed by the liberation of nascent oxygen in contact with the aluminium surface. The skin of oxide so formed has the ability to absorb aniline dyes, so that a great variety of pleasing effects can be obtained. Door, window, and other fittings made up of cast and wrought aluminium alloys, and finished as described, in a range of colours, have been on the market for some time.

Very pleasing results can also be obtained by the use of the Jirotka solution dipping process, which will give a variety of finishes on wrought or cast aluminium, including an iridescent finish, various shades of bronze or copper, and dark- or leaden-coloured finishes similar to old pewter. Metallic solutions are employed. Pleasing finishes for certain purposes are given treatment in solutions of potassium bichromate, giving a dark slate colour, which is very permanent and hard.

Aluminium foil makes increasing inroads into the chocolate-wrapping industry, from which tin has been entirely displaced. For this purpose the metal is usually embossed with some pattern in the final rolling operation, and then dyed a bright colour on one side. Aluminium foil is much cheaper than tin-foil for the wrapping of substances which will not be likely to lead to corrosion, such as cheese, for which tin-foil is still employed. An application of aluminium foil of relatively recent discovery is for heat insulation under the trade name of "Alfol." "Alfol" is merely crumpled aluminium foil which, when suitably packed round (for example) steam pipes and then protected externally, is found to have remarkable heat-insulating properties. It finds employment in the provision of heat insulation in the large meat and milk transport vehicles now generally employed for the transport of meat and milk which it is desired to maintain at a definite low temperature. An application of aluminium foil lies in interior decoration, a very pleasing effect being obtained by using foil as wall-covering, especially with jade-green paintwork and jet-black for knobs of doors, etc. This colour scheme, using aluminium foil, has formed part of the interior decoration of the Savoy Hotel for several years.

General Castings.

The field of application of general castings continues to expand despite the depression of most other industries. There is no doubt that this is due in part to an increasing appreciation of the advantages which can be derived from the use of aluminium.

The heat-treatment of aluminium alloy castings has increased of late to a considerable extent, and, generally, where higher strength than usual is required, heat-treatable alloys are specified by customers when ordering. Probably, at present, heat-treatment of castings is principally applied to internal-combustion engine pistons, although large numbers of other parts, especially for motor transport such as brake shoes, cylinder heads, etc., are heat-treated.

The use of heat-treated aluminium alloy forgings is expanding, and, where the highest possible mechanical properties are desired, it is usual to employ for internal-combustion engines drop-forged pistons and connecting rods. Fig. 3 shows aluminium air screws.

The field of pressure die-castings has always been a large one, embracing such small articles as vacuum cleaner, gramophone and radio parts, interior mechanisms of weighing machines, carburetter bodies, motor-car door and window furniture, and a multitude of odds and ends far too numerous to mention.

Latest Technical Developments.

In making a survey of recent technical developments of aluminium within the narrow limits of this article it is not possible to confine the attention to advances made specifically during the last year; progress in such matters is gradual and continuous; several matters of specially recent note do, however, occur to the mind.

Casting of Rolling Slabs.—In the casting of rolling slabs with improved soundness, the recently announced R.WR. system is probably of importance. This process aims at a progressive, controlled, freezing of the metal, which is sure

to have good results by improving the rolling-mill product and reducing waste losses. According to this process, metal is admitted to a preheated mould and maintained entirely molten until the mould is quite full. By a cooling device the solidification of the metal is then started at one surface and proceeds progressively to the opposite surface, uniformly and rapidly. By this device variation of the rate of solidification of rolling slabs, and of different parts of the same rolling slab, are to a large extent eliminated and more uniform results should be obtained.

Gases in Aluminium.—In regard to the problem of gases in aluminium alloys considerable progress has been made—notably by the British Non-ferrous Metals Research Association. Gases in aluminium alloys as is well known, give rise to the objectionable pinholes or specky metal in castings—especially in heavy sand castings. The main objection to pinholes in castings is that they signify unsoundness with concomitant weakness, and often lead to porosity of castings which may be required in service to withstand pressure. The pinholes do not generally appear on "as cast" surfaces, but are only revealed by either machining or polishing. Pinholes or specky metal do not usually appear in gravity or pressure die-castings, on account of the rapidity of freezing of the metal in these processes, which leads to retention of the gas in solution in the metal. Pure aluminium rarely shows any pinholes at all, even when it may contain 30/40% of its volume of gas, but on the addition of some other element, such as copper, the pinholes at once make their appearance—presumably due to the disturbance of the gas solubility equilibrium, which causes its rejection on solidification. The pinhole problem is not generally encountered in the production of sheet, by virtue of the facts that, as already mentioned, pure aluminium does not usually show pinholes even if sand cast, and that the rolling slabs, extrusion billets, etc., are always cast in iron moulds, giving such a rapid rate of cooling as to prevent evolution of any gas at all.

In melting, the solubility of molten aluminium gases in alloys has been demonstrated to be greatly increased as the temperature is raised and the time maintained molten is lengthened.

The deleterious effects of water vapour in contact with molten aluminium alloys have been demonstrated. It appears that water vapour is decomposed into hydrogen and oxygen, the hydrogen being absorbed. In order to avoid gas absorption during melting it is, therefore, necessary to guard against water vapour from such possible sources as the heating fuel, whether it be coal, coke, gas, or oil, the products of combustion of which are liable to contain water vapour. It even appears probable that unusual humidity of the atmosphere—as, for example, on very damp days—may, by bringing unusual amounts of water vapour in contact with the molten surface, allow of some H_2O conversion taking place and of hydrogen being absorbed. A further important source of gas in aluminium alloys has been found to result from the melting of aluminium which has been exposed to corrosive conditions; that is to say, if aluminium ingot or scrap is left out-of-doors, or in a damp place where it can corrode superficially, the moisture reacts with the metal surface, forming aluminium hydroxide, and leading to the absorption of hydrogen into the solid metal. On remelting the absorbed hydrogen is retained in solution until the metal solidifies in the mould; it is then rejected and gives rise to pinholes. The extent of unsoundness depends upon the type of exposure and its duration, and appears to be more noticeable in "Y" and 12% silicon aluminium alloys than, for example, in alloys of the 2L 5 and 3L 11 classes.

Experiments have shown that metal maintained in a dry atmosphere indoors for six months is not deteriorated in this way, but exposure for six months out-of-doors, followed by melting and casting, gives metal showing a large number of pinholes. Intermediate results are obtained with variation of the conditions. It appears to be impossible to restore exposed and deteriorated metal by any method other than by remelting and treating by some means for the removal of the gas.

This practical research indicates, therefore, that it is necessary to store aluminium in dry places if stocks are to be held for a long time. It is also obviously of importance to bear this fact in mind in considering the use of cast scrap from, for example, motor-car crankcases, etc. Such scrap is almost invariably considerably corroded, and will lead to an appreciably proportionate gas content in castings made from it.

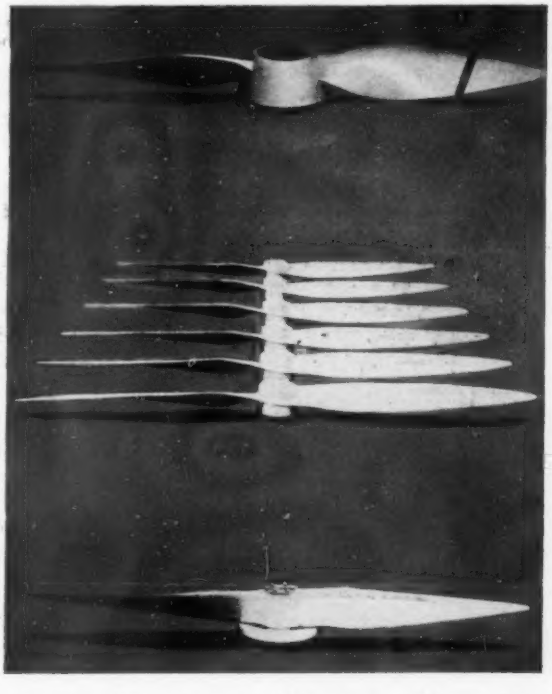


Fig. 3.—Three different types of metal airscrews, made from duralumin forgings. The top one represents the actual propellor fitted to the Schneider cup winner.

Generally it is difficult to prevent some additional deterioration during melting, especially in furnaces using coal gas or oil as fuel, owing to the high content of water vapour in the furnace atmosphere resulting from the combustion of such fuels. It appears fairly certain that coke-fired crucibles are less likely to lead to damage of good metal than either gas or oil furnaces, whilst electric melting is still better, and with proper care makes it possible to melt aluminium without the absorption of any gas at all. With electric melting the atmosphere can be artificially controlled. Coal is particularly bad, since it gives off a large volume of water vapour on combustion.

Methods of Eliminating Gas.—Various methods have been suggested for the removal of gas from molten aluminium. Some of these are effective, whilst others are less so. The first method which was suggested originated at the National Physical Laboratory, and involved very slow cooling of melts whereby the gas would be driven out to the surface, and then, on subsequent remelting, the material would be relatively gas-free. This method was passive, and more positive methods have since been suggested, such as the passage of a stream of pure dry nitrogen, with or without chlorine, in equal proportions, through the molten metal for sufficient time for combination of the chlorine with the gases present to be effected and for the nitrogen, which itself is insoluble in aluminium, to mechanically disturb and expel all gases present. This treatment is carried out at temperatures just above the melting point of the metal or alloy.

Development of this idea has led to experimentation with a number of volatile chlorides such as carbon tetra-

chloride, titanium tetrachloride, and boron trichloride, all of which are efficacious to a certain extent. In utilising these substances, however, considerable care has to be taken on account of their dangerous nature and of the fumes, which must be removed by suitable fans and hooding.

New Alloys.

New alloys, for which "super" properties are claimed, appear continually. The number of aluminium alloys which are announced and patented every year must be very considerable. Although special claims are made for them there is often nothing to justify such claims, and the alloys are not infrequently merely modifications of alloys which have long been known, but which some investigator insufficiently well informed as to the advances in metallurgy thinks he himself has discovered. Large numbers of these "new" alloys are never heard of after the first announcement. Perhaps the principal development of late has been along the lines of harder alloys for internal-combustion engine pistons, and also in alloys for pistons with low coefficient expansion. Among the harder alloys must be mentioned the still relatively new RR 53, which is used as a casting alloy, and RR 56, a forging alloy, both for pistons. These alloys are, roughly speaking, of the Y-alloy type, and contain small amounts of copper,

Fig. 4.—Motor pistons, from 2½ cwt. to a few ounces, in heat-treated B.E.S.A., "3L 11," and "2L 8" aluminium alloys. (Courtesy of W. Mills, Ltd.).

nickel, silicon, magnesium, iron, and titanium. By suitable heat-treatment die-cast pistons in RR 53 can be made to show a Brinell hardness of 130-140. The thermal expansion of these alloys is not greatly different from that of the older-known alloys used for pistons—namely, Y alloy and "2L 8." It has appeared desirable to develop alloys with somewhat lower coefficient of expansion, and these are found in the materials of hyper-eutectic silicon, together with small amounts of half a dozen other common elements. The coefficient of expansion per degree centigrade of such an alloy is 0·000020, while the coefficient of Y alloy is 0·000024, and the coefficient of 2L 8, 0·0000246. Such low expansion alloys as this high-silicon type are employed in some cases in conjunction with alloy steel for liners, which itself has relatively high expansion. Machining of the high-silicon piston alloys presents difficulty; unless such special cutting tools as tungsten carbide, known as Widia, are employed, it is necessary to use diamonds for finishing. The reason that these alloys are hard to machine is due to the high content of silicon. Although in the early days of the development of these alloys it was believed that the best results were to be obtained by the use of silicon as high as 22%, it is now found that a reasonably low coefficient of expansion can be obtained by using an alloy with not more than 13% of silicon, and about 2% of copper and 1% of manganese, and this type of alloy is considerably easier to cast and machine. Although there have recently been some rather extravagant claims in the press for aluminium alloys containing chromium, the author is not aware of any specially useful alloy containing this element having been so far developed, although it is certain that considerable effort has been made to find some such alloy.

Corrosion-resisting alloys are always a field of interest to the metallurgist, and apart from K. S. Seawasser and the ordinary eutectic-silicon aluminium alloys, which are now well known by virtue of their corrosion resistance, no specially new strides have been made. The alloy MG 7, which has now been developed for some little time, and which is an aluminium-rich alloy containing a fair proportion of magnesium, is finding considerable use as a wrought material in fields where corrosion resistance is required. It is probable that the greatest tonnage of corrosion-resisting alloys, especially in the form of castings, is still in the modified aluminium-silicon alloys. Of late there has been an increased tendency to use an aluminium-silicon alloy, especially for decorative work out-of-doors containing not more than 6% of silicon and unmodified. The aluminium casting alloys containing several per cent. of magnesium have excellent corrosion-resisting properties on account of their ability to form a magnesium-oxide film upon the surface. The film initially formed exerts a protective action upon the subjacent metal and prevents oxidation proceeding.

The Institute of Metals Annual Meeting.

The twenty-fifth annual general meeting of the Institute of Metals will be held on March 8 and 9, at the Institution of Mechanical Engineers, London, under the chairmanship of the President, Sir Henry Fowler, K.B.E., LL.D., D.Sc. The meeting will begin at 10 a.m. on March 8, with the presentation of the report of Council for 1932 and the announcement of the results of the election of officers for the year 1933-34. In the evening the Institute's annual dinner and dance will be held at the Trocadero Restaurant.

At this annual meeting the following papers will be presented for discussion:—"Some Effects of the Addition of Tellurium to Lead," by W. Singleton and B. Jones, M.Met.; "The Interpretation of the Tensile Test (with Reference to Lead Alloys)," by Professor B. P. Haigh; "Experiments on the Effects of Variations in Mould and Pouring Temperatures on the Macro- and Micro Structures of Some Low-Melting-Point Metals and Alloys," by Frances D. Weaver, B.Sc. (Mrs. Harold Heywood); "The Physical Properties of Zinc at Various Stages of Cold-Rolling," by R. Chadwick, B.A.; "The Fatigue-Resisting Properties of Light Aluminium Alloys at Elevated Temperatures," by J. W. Cuthbertson, M.Sc.; "The Electrical Conductivity of Aluminium Wire," by A. J. Field, M.C., B.Sc., and J. H. Dickin, B.Sc.; "Graphitic Silicon. Heat-treatment, and the Electrical Conductivity of Aluminium," by L. H. Callendar, Ph.D., A.R.C.S., F.I.C.; "An X-ray Investigation of the Copper-Aluminium Alloys," by A. J. Bradley, Ph.D., and Phyllis Jones, Ph.D.; "The Distribution of Porosity in Copper Ingots," by N. P. Allen, M.Met.; "The Equilibrium of the Reaction between Steam and Molten Copper," by N. P. Allen, M.Met., and T. Hewitt, M.Sc.; "An Investigation of the Effects of Hydrogen and Oxygen on the Unsoundness of the Copper-Nickel Alloys," N. P. Allen, M.Met., and A. C. Street, B.Sc.; "Note on the Influence of Volatile Chlorides on Magnesium and on Copper," by J. D. Grogan, B.A., and T. H. Schofield, M.Sc.; "The Application of the Diamond Pyramid Indentation Test to Copper and Copper-Rich Alloys in the Form of Thin Strip," by M. Cook, M.Sc., and E. C. Larke.

In connection with this meeting, a visit to the headquarters of the British Non-Ferrous Metals Research Association has been arranged, the laboratories of which will be open for inspection. There will be on view exhibits to illustrate the progress and results of a number of the researches carried out for the Association.

The Iron and Steel Institute.

The Council of the Institute has decided to award the Bessemer Gold Medal for 1933 to Dr. W. H. Hatfield, Director of Research in the firm of Messrs. Thos. Firth and John Brown, Ltd., in recognition of his distinguished services in the advancement of metallurgical science, and of his valuable researches in connection therewith.

Rust- and Acid-Resisting Steels

Progress and Future Trend

By W. H. Hatfield, D.Met.
(The Firth-Brown Research Laboratories.)

The austenitic steels still require and will receive great attention from metallurgical investigators, but intimate collaboration between producer and user will do much to remove outstanding difficulties. In this article the author shows the increasing application of these steels in those fields where high corrosion-resistance qualities are of primary importance.

IT is of great interest to review the progress which has been made in the provision of steels capable of resisting corrosion and the deteriorating effects of high temperatures. It can, in truth, be said that 20 years ago this invaluable series of steels largely existed only in the minds of one or two investigators. The subsequent development is the principal outstanding achievement of modern metallurgy.

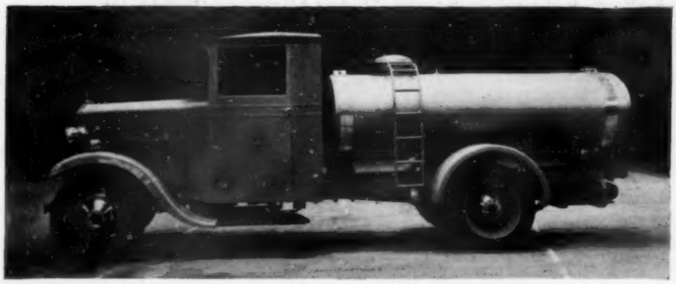
As is well known, the first stainless steels to be produced in quantity were essentially the 12% to 14% plain chromium class, the carbon content of these steels being varied to suit particular applications. Whilst this valuable class of stainless steels fulfilled many requirements, and still does meet many conditions, nevertheless, both as regards corrosion resistance and also ease of manipulation and fabrication, the plain 12% to 14% chromium steels are not suited to all purposes. Subsequent research showed that steels with higher percentages of chromium, together with considerable quantities of nickel, exhibited superior corrosion resistance, at the same time giving increased ease of manipulation and fabrication.

By courtesy of Messrs. Thompson Bros. (Bilston), Ltd.
Essential oil stills, made of Staybrite steel.

The steel sometimes referred to as 18/8 austenitic chromium-nickel steel is based upon the results of extended research, and has an optimum resistance to a wide range of corroding media. It contains, essentially, about 18% chromium and 8% nickel, and has a low carbon content. This steel is now fully developed and has received world-wide recognition. Its production, both in Europe and America, has attained a tonnage which could not have been anticipated, and organised production in efficient plants, under excellent technical control, results in a very high standard of product in the form of sheets, strips, plates, bars, forgings, castings, tubes, and wire. A large number of extremely successful applications of the material are well known, and where cases have occurred in which the material has not proved successful, the facts have been published; by such procedure technical progress is facilitated, and a material rapidly assumes its proper niche in the mechanical arts.

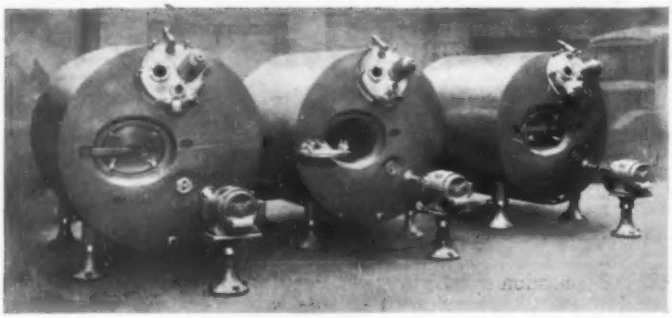
The response of a metal to corroding influences is obviously determined by its composition and structural condition and the composition, concentration, temperature, and physical condition of the corroding media. These constitute such a complex set of variables that, for practical purposes, the common-sense answer is a test-out under working conditions.

Some years ago the author devised the boiling copper sulphate-sulphuric acid test for determining the best condition of these austenitic steels for chemical-plant applications; and subsequent research, chiefly in the laboratories of Firth-Brown and Krupp, has provided the necessary modifications required to give immunity under such an "acid" test. It cannot, however, be too strongly emphasised that only in certain applications is steel called upon upon to resist the drastic conditions reproduced by this test, for example, foodstuffs are not composed of boiling sulphuric acid containing copper sulphate, neither are spoons and forks nor vegetable dishes washed in such a medium. In other words, the later developments of this class of steels relate to particular applications, and when this is fully realised even greater progress will take place in the extended use of the materials. This article does not provide space to detail the vast amount of tested data now available to assist the manufacturer in his work.



By courtesy of Messrs. Thompson Bros. (Bilston), Ld.
Tank for milk transport.

The recent and rapid growth of the aircraft industry has involved the increasing use of several of the modern corrosion-resisting steels; it is now possible to supply super corrosion-resisting steel with remarkably high mechanical properties, as instanced by a proof stress of 60 tons per square inch; and the stainless all-metal aeroplane is now an accomplished fact.



By courtesy of Messrs. Aluminium Plant and Vessel Co., Ltd., London.
Ice-cream mixing tanks, the inner vessels of which consist of welded Staybrite steel sheets.

The production of paper in all its processes, from the wood pulp to the finished product, again offers a useful field. In the early stages of the digestion of pulp with sulphite liquor, the corrosive conditions are severe and demand a highly resistant material such as the steels under discussion, whilst, in the later stages, where freedom from discoloration is desirable, again the steel is successfully used.

In the manufacture and storage of fine chemicals and pharmaceutical products, it will be realised that the various portions of plant should be made from material which is entirely unaffected by the contents of the vessels, and, moreover, that the contents should in no way be contaminated In both these respects the steel has shown advantages over other metals and also glass-lined plant, for steam-jacketed vessels, mixers, and storage tanks. One of the largest factories for pharmaceutical products in Europe is now equipped with very extensive and varied plant in the 18/8 steel.

It so happens that the development of the production of nitric acid by the fixation of atmospheric nitrogen, in the now largely used high-pressure catalysis processes, was coincident with the development of these rust- and acid-resisting steels, and as a result of the insight and courage of the officials of the Billingham factory, of the Imperial Chemical Industries, Ltd., the 18/8 steel was first successfully applied in this field. With the possible exception of the concentrated acid at, or near, boiling point "Staybrite" steel is resistant to nitric acid of any concentration and at all temperatures, so that all portions of the plant, from the oxidation of the ammonia to the final storage and transport of the nitric acid, are successfully made in this steel. In fact, both in this country and abroad, large quantities of the steel are in actual use in the form of oxidiser coolers, absorption towers, storage tanks, transport tank cars and drums, pipe lines, valves, and other auxiliary plant. The increase in economy and safety, ensuing from the use of this steel, is well brought out by citing the case of transport of strong nitric acid in Staybrite containers (either drums or tank cars) as compared with the old method of transport in glass carboys.

Another industrial process which has developed rapidly during recent years is that involving nitration by means of "mixed acid"—viz., a mixture of nitric and sulphuric acid. In the normal way the austenitic steels are not claimed to withstand sulphuric acid, but it is fortunate that, when associated with certain acids or salts, the resultant mixture has no effect upon the steel. Nitric acid is one of the reagents which, when present with sulphuric acid, prevents attack of the latter acid upon the steel, as a result of which it has been possible to utilise it in the nitration industry.

Milk process heating vessel, made of Staybrite steel.
By courtesy of Messrs. Aluminium Plant and Vessel Co., Ltd., London.

The advent of these special steels has proved of immense

By courtesy of Messrs. W. A. Atkinson, Nottingham.
Dye tank, made from Staybrite steel.

value to the dyeing and textile industries. The use of these steels for dye-vats, for example, has resulted in considerable economies and increase in efficiency by the elimination of stains and damage to fabrics, the ease in changing from one colour to another, and the lengthening of the life of the plant.

A résumé of the usefulness of these special corrosion-resisting steels would not be complete without reference to their application to the numerous branches of the food industry, with particular reference to dairy work. In this latter connection it is being used extensively, ease of cleansing and complete freedom from contamination of the product proving very valuable assets. Both road and rail transport tanks are now in regular use, in addition to almost every item of dairy equipment.

Where the applications consist of the fabrication of articles from softened and descaled, or preferably, polished sheets, by easy amounts of cold work, either by pressing or spinning, no difficulties are encountered. If much cold work is applied, it is necessary, in order to relieve stresses and permit further cold-work, to soften by heating to the particular temperatures required for the type of steel used. Quick cooling from the high temperature is essential.

There are cases, however, where fabrication demands the application of heat, as in pressing thick plates, or in

(*Continued on page* 129.)

Developments and Future Trends of the Non-Ferrous Tube Trade

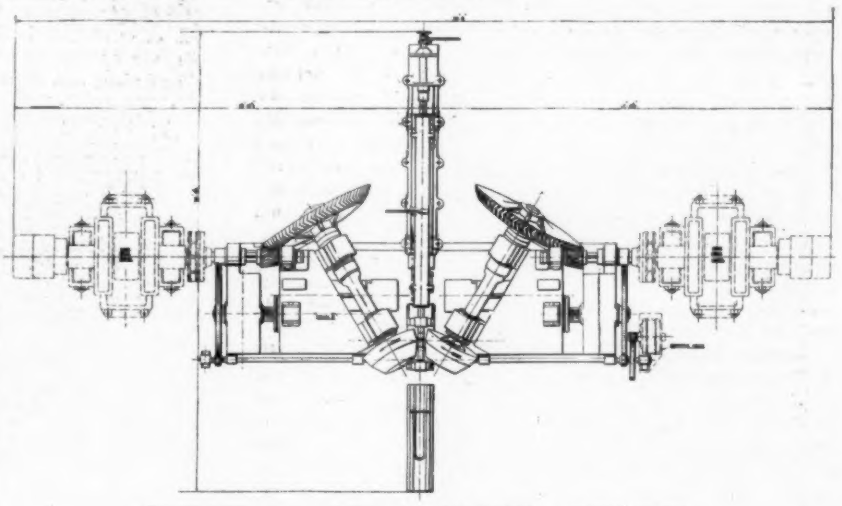
By Gilbert Evans

The position of the non-ferrous tube trade is reviewed, the development of the rotary piercing and extrusion machines discussed, together with future possibilities for economical production and application of tube in various forms.

THE abnormal depression in trade generally throughout Great Britain is acutely reflected by the state of affairs existing in the manufacture of non-ferrous metal articles, especially in that of brass and copper tubes. The absence of demand for this particular branch has resulted, in the case of the larger firms, in great reductions in staff and workpeople, cutting in piece-work rates and amount of actual productive manipulation in the course of manufacture. The effect of such economies is to a degree helpful, but further causes for the decline are not far to seek. Instability of the copper market, cutting of the naval programme, economy of building for maritime purposes generally, and of ocean liners in particular; fitting of locomotives with steel tubes, and competition with special steel for condenser and locomotive tubes are all contributory to the decline. Week after week market reports are uninspiring and unvarying. "Little change in the non-ferrous tube trade. Business moderate, demand poor; none of the mills fully employed; no call for large tubes, and keen competition and cut prices for small." Add to these facts that foreign manufacturers, helped by export and import duties, are in a position to supply their own country's demands, and by the installation of modern improved manufacturing plant (mostly of British origin), actually compete in foreign markets which up to recent years were practically dependent on British non-ferrous material. It will not be a matter of surprise that some of the great railway concerns, accepted as wedded to the use of speciality or proprietary brass and arsenical copper mixtures for locomotive boilers, are adopting steel tubes for the purpose, a lead established by the Great Western, and already under consideration by some of the Dominion concerns. In order to counteract the chemical defects set up in the use of steel tubes for locomotives, copper ends and ferrules are in some cases brazed on at firebox and smokebox ends of the tubes.

Reviewing the position of condenser tubes, here again steel makers are intensively concentrating on the production of acid- and heat-resisting material, based, presumably, on the properties of stainless steel. This statement is supported by a leading Swedish charcoal-steel manufacturer, who considers that in approximately five years' time at least 90% of their total output of material for tube manufacture and of tubes themselves will be of stainless steel. This outspoken avowal, backed up by the personal inspection of a large range of samples adapted to various uses, convinces the writer of the practical value of their suitability for various uses in competition in fields hitherto considered confined to the non-ferrous trade. Stainless steels have been subjected to large-scale corrosion tests, using alkaline compounds, inorganic acid and acid mixtures, organic acids and salt solutions, and the results of the tests showed that the steels were almost practically impervious. This provides matter for deep consideration on the part of manufacturers of non-ferrous tubes.

Consideration of the foregoing preliminary analysis of conditions may give rise to the questions: Has the author reviewed the subject from too grave, morbid, and depressing an aspect? Have the British manufacturers kept pace with foreign competition by the installation of modern improvements and addition to plants for economical and efficient production? Has a finger been kept on the pulse of the world's requirements?



General arrangement of rotary piercing machine. Evans' patent.

To the first query one would reply: An intensive analysis of the existing state of trade and its immediate outlook is a definite and convincing answer. Secondly: Most definitely the British tube manufacturers have adopted and thoroughly exploited methods of late years which may be said to have revolutionised their special branch of the non-ferrous trade; and here it may be stated, from personal experience, that the universal opinion held abroad is that Great Britain is still the pioneer in the non-ferrous tube trade, a result of the blending of scientific research with practice. This progress will be referred to later in this article, when discussing modern plant and methods; but in reviewing improvements in methods of manufacture as applied to various trades, it is remarkable that in the making of non-ferrous tubes a greater advance has been accomplished than in any other associated branch. As recently as 1928 the considered written opinion of a recognised expert was to the effect that as long as we have non-ferrous tube making so long shall we have casting on sand cores. Events have moved rapidly since that statement was made, but since the adoption of the extrusion process a number of special mixtures have been proved amendable to such treatment, especially cupro-nickel, aluminium bronze, and 60/40 composition. Other mixtures, 70/30, 70/29/1, etc., have been, from a commercial standpoint, fairly successfully manipulated, but with such a

By courtesy of Serck Tubes, Ltd.
Billets for tube extrusion entering furnace.

narrow margin of safety in heating that it has not been universally adopted, and casting on sand cores has not been entirely replaced even in the most progressive factories. Although, in time to come, the small casual manufacturer of brass tubes, to whom the initial cost of installing modern plant is prohibitive, will still rely for brass shells on the split moulds and sand cores, the great advance of extrusion will eventually entirely supersede what one may term the old-fashioned method with sand cores.

The development of rotary piercing as applied to copper tube production is an example of this advance. The earlier methods of production include boring and turning the solid billets; casting on sand cores, with subsequent boring and turning; and the piercing of solid billet by hydraulic pressure. Of these methods that of piercing by hydraulic (vertical and horizontal) still exists, but the introduction of the rotary piercing machine has been almost universally adopted at home and abroad.

Considerable discussion has arisen as to which of the latest methods—rotary piercing or extrusion—is most efficient, and, with every diffidence, the writer opines that for tubes up to 2 in. dia. of limited weights the decision favours extrusion, but for larger diameters and increased weights preference is given to the rotary machine, bearing in mind that a combination of the two methods—viz., piercing in vertical hydraulic press and transferring with retained heat for expansion in the rotary type—may produce the ideal tube. (Note, any eccentricity in the wall from piercing can be considerably rectified in the subsequent rotary process, and to this is added the economy effected in fuel and labour by the elimination of a reheating).

Considerable secrecy is being observed with regard to a reducing process for dealing with medium-diameter thick-walled tubes of long lengths, which has been adopted with success in Continental factories. The principle is that of the rotary machine. But, in a final reference to this branch of the tube trade, it is as well to state that plant capable of piercing solid billets, up to 9 in. dia., and expanding in two passes through the rolls to an ultimate diameter of 20 in., has been supplied by British makers to Continental competitors. At the moment, however, the writer is only aware of one machine in use in England with such elastic limits, and where a demand for an approximately large diameter has arisen the expansion has been a laborious and extended one, conducted by "plugging" up on slow-speed chain benches, a method accompanied by the extra cost of annealing and pickling, in addition to extra labour cost. Certainly the view may be taken that there is a decidedly limited demand for tubes over, say, 15 in. dia.; but their manufacture has to be taken into account, and provision provided to cope with them in order to secure the balance of the whole pending order.

A comparison of casting methods must necessarily be carefully undertaken, seeing that pot-casting, ladle casting from reverberatory furnaces, and melting in electric furnaces are all in common use at the present time, while, in some instances, after very extended trials, pot-casting from coke pit-fires has been reverted to, to the partial elimination of furnaces of reverberatory type. On the whole pot-casting (to use the trade term) still retains its hold in the trade for reliability. In common with the product of pot-cast furnaces, the product of the electric type is uniform and reliable in quality. There is a divergence of opinion as to the claims of both from the economical point of view. The capacity of both pot and electric furnaces is not so great as with the reverberatory furnace, which is often up to 20 tons, and, of the three methods, is certainly the most economical, if not so dependable at times in quality. In the manufacture of locomotive tubes, generally specified in lots of 500, a more reliable average test, chemically and mechanically, is obtained from a reverberatory charge, which is often sufficient to produce material covering 1,000 or more tubes for inspection. The same applies to certain electric furnace installations. The arsenical contents of the copper for locomotive tubes are 0·35% to 0·45%, and for steam pipes, 0·45% to 0·55%; so that it is possible for a single melting to comply with both specifications.

It is proposed to consider briefly extruding presses, which are of two types—viz., horizontal and vertical,—capable of exerting ultimate total pressures of from 500 to 3,000 tons from direct pump or accumulator supplies at from 1 ton up to 3 tons per square inch. Except for the production of large tubes the horizontal press has been superseded almost entirely by the vertical. Many drawbacks of the horizontal type, adapted for tube or hollow work, have been eradicated, the chief of which was the liability of producing hollows with eccentric walls. The causes of this defect were various; for instance, the billet, due to sweating in the heating furnace, loses its original diameter and is rendered too small to adequately fill the chamber, so, following the law of gravity, the billet lies on the lower part of container with a considerable space at top, inevitably producing unequal walls, as the working centre of the piercing and extrusion mandrel is directly in line with that of the container. Again, allowing correct working conditions, there is the probability of the horizontal piercing and extruding mandrel buckling or bending while in action. This refers to the smaller sizes in particular. These weaknesses are considerably modified in practice, and in operation of vertical presses.

Further contention has arisen as to the relative merits of fixed versus loose or floating piercing and extruding mandrels. After extensive and close observation of both methods one wholeheartedly and definitely favours the loose tools for the following reasons: The loose mandrel, which is centred to the billet by a guide brush, allows a little give and take in its application to the material to be pierced and extruded. The fixed mandrel makes no allowance. Loose tools are changeable at every piercing operation if desired, thus allowing two or three sets of the same size to be worked in rotation, with absorption of heat reduced in their working life. Following careful practical study of various Continental and English manufactured extrusion presses, one gives a qualified vote in favour of the plant manufactured under the patents of Messrs. The Serck Radiator and Tube Co., Ltd., Birmingham (manufactured by Fielding and Platt, Ltd., Gloucester), in which, in addition to floating tools, are included the moving container, an arrangement which, due to the container

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METALLURGIA

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For FEBRUARY, 1933.

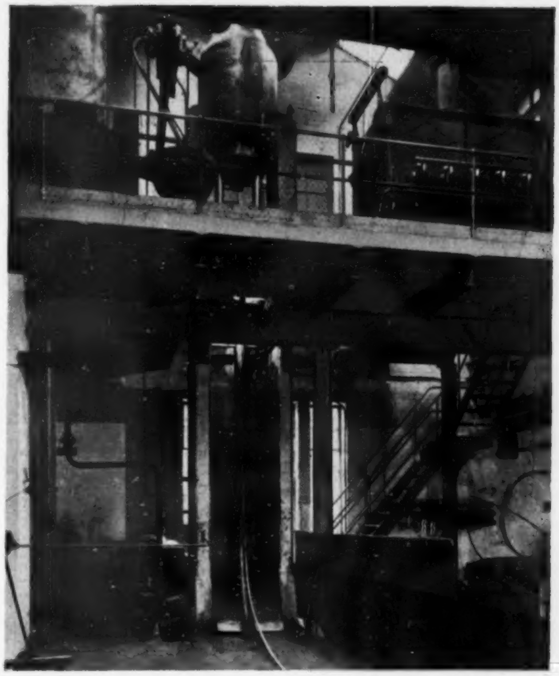
travelling with the billet in the extruding action, reduces the local impingement between material and container to a minimum.

In the important matter of the finishing processes of cold-drawing, here again one is of the decided opinion that British-manufactured draw benches have no superior in their adaptability for this process. There is a tendency in both Germany and America (France follows our lead) to save initial cost by substituting deep steel H-sections for the solidity of the cast-iron main bodies on which the endless chain travels. Almost inevitably, and in spite of stiffening distance-pieces bolted between at intervals, these girders do not subdue the tendency to "chattering" whilst the tube is being drawn over the mandrel head or on the bar—as the case may be—and through the die. As a consequence the ribbing on the tube surface, directly due to this chattering, is a defect most difficult to counteract, and even more difficult to remove in subsequent drawing operations. In regard to travelling speed of drawn bench chains, the Continental tendency is to run at a higher velocity than is generally accepted in England, but it should be remembered that it is not the time taken in the actual operation of drawing, but the time occupied in preparing for the pass which concerns the engineer most.

On the comparative merits of hydraulic and chain benches an everlasting argument may be raised and debated. The chain pulls the tube through, and is adaptable for mandrel or bar work, while the hydraulic push bench forces the tube to compress on to the solid bar and forces bar and tube through the die. In both operations an adjustable releasing arrangement at the back of the die loosens the tube, which is then quite free from the bar, at the end of its pass, and allows it to be quickly removed as the main ram is returned in readiness for the next shell. In the use of the chain bench the tube and bar are brought back clear of the die and reversed on a swivel for bar extraction.

A great deal of discussion has arisen as to the merits of a fixed drawing bar and die as applied to draw or push benches of the hydraulic type, as compared with a free bar and die—that is, these tools being allowed to float; and the writer unhesitatingly decides in favour of the latter method after exhaustive experiments, which can only briefly be described here owing to the exigencies of space. The bench on which the tests were carried out had the $5\frac{1}{2}$-in. dia. drawing bar screwed rigidly in to the cross-head of the main ram, while the drawing die was *deliberately* fixed securely with its centre nearly $\frac{1}{8}$ in. below the working centre of the bench. A tube was specially prepared by being turned on the outside to arrive at comparatively perfect concentricity of wall. This tube was cut into four lengths, and the very slight variation in thickness at six points of each piece carefully noted. The same bar and die were used for each length of tube. Pieces No. 1 and 2 were put through the operation under the conditions already set out—viz., fixed bar and die out of centre. For the second test the die was loosely held in an approximately central position, and the screwed end of the bar was released to allow the heel in contact with the crosshead to find its own setting. Some of the results noticed were: a decided tendency in the fixed drawing bar to buckle in the shape of a long bow; the setting-up of great frictional heat in the tube being drawn; a distinct increase in duration of drawing period; and, most important of all, a reduction of $\frac{1}{16}$ in. more in the top wall thickness than at the opposite point of the circle. The result of the test with floating tools confirmed the writer's theory that the last-mentioned conditions were correct for this type of draw bench. Measurements after the latter operation showed that a uniform reduction had been obtained, the pieces were perfectly concentric, and the drawing bar itself centred in relation to the drawing die, while the tendency to buckle when in compression was not observable.

Methods of annealing may be referred to briefly by expressing the opinion that, as in America, Germany, and other Continental countries, electric furnaces are now coming to the front, no doubt due to the fact that considerable development has been effected during recent years in the design of furnaces for the use of electricity as a heating medium. Both gas- and oil-fired furnaces have, however, made considerable progress in supplying the conditions required for economical and accurate production. Control of atmosphere within the furnace as well as of temperature is being aimed at, and modern designs are certainly progressive. With electric furnaces the initial installation costs are high, yet the writer is able to testify to the economical working of an electric furnace having an overall length of 80 ft., consisting of charging chamber, annealing chamber, cooling and discharging chamber, through which the tube is automatically fed, and is not touched by hand after being placed at the charging end. In this instance the rate of progression during the annealing process is capable of adjustment to suit various compositions of metal.



By courtesy of Serck Tubes, Ltd.

1,000-*ton extrusion press in operation in tube production.*

In regard to moulds for casting solid billets for rotary piercing and extrusion the accepted practice is to use cast-iron moulds. Close, grey iron, free from internal defects, is used and the moulds are bored parallel, but the writer has had the opportunity of inspecting the modern development in water-cooled moulds, the use of which will undoubtedly in the near future, in view of the results obtained, become universal.

In conclusion it may be asked: Are there any new economical methods to be considered? Are there new openings for the exploration of trade? There can be no doubt that technique has improved, which has facilitated production, with the result that tubes are of better quality and economically produced. It has been suggested that non-ferrous tubes should be made compulsory for domestic purposes, such as water service, etc., but care is evidently necessary in view of the appearance of green staining and corrosion being noticeable when using certain waters. Although suffering considerably from the general depression, the application of tube has been widened, and, with a return to normal conditions, it may safely be assumed that the trade will participate since it has had the foresight to prepare for improving conditions which are slowly becoming manifest.

Reviews of Current Literature.

Economic Control of Quality of Manufactured Product.

THE primary object of industry is to set up economic ways and means of satisfying human wants, and in so doing to reduce everything possible to routines requiring a minimum amount of human effort. The fact that the prevailing distress in civilised countries is due largely to the remarkable way in which production has been speeded-up during recent years does not destroy this fundamental principle, rather does it imply that progress has become unbalanced, and the ability to produce has developed at a more rapid rate in comparison with the ability to absorb the products of industry. The present economic position is probably due to a lack of control of production in relation to distribution, which opens very contentious problems. This book, however, deals with the economic control of quality of the manufactured product, and the author claims that by the use of science, extended to take into account modern statistical concepts, it has been found possible to set up limits within which the results of routine efforts must lie if they are to be economical. Deviations in the results of a routine process outside such limits indicate that the routine has broken down, and will no longer be economical until the cause of trouble is removed.

A considerable amount of work has been done in developing statistical methods on the scientific side, and there is ample evidence that they provide logical methods for the control of operation, for the research engineer, the plant superintendent, and the production executive. Improved statistical machinery is now available, and there are indications that it is being applied, in some instances, by those responsible in practical affairs. In this book the author comes to the conclusion that there is an objective state of control, making possible the prediction of quality within limits, even though the causes of variability are unknown. He gives evidence to indicate that through the use of statistical machinery in the hands of an engineer capable of making the right kind of hypotheses it appears possible to establish criteria which indicate when the state of control is reached.

The text is divided into seven parts, each of which is subdivided into chapters which deal with well-defined aspects of the subject. Part I. is concerned with an introduction in which the characteristics of controlled quality, scientific basis of control, and the advantages secured from control are considered. Methods of expressing quality of product are discussed at considerable length in Part II., in which not only is the term quality defined, but also methods of presenting and using data. The basis for specification of quality control is given in Part III., while Part IV. covers sampling fluctuations in quality. The succeeding parts deal with allowable variability in quality, and quality control in practice.

In summarising the fundamental principles, the author states that our understanding of the theory of quality control requires that our fundamental concepts of such things as physical properties, physical laws, and causal explanations undergo certain changes, since industrial development rests upon the application of the laws relating the physical properties of materials. In considering the need for control as an integral part of any industrial programme, five more or less distinct steps can be distinguished. These embrace a study of the results of research to provide principles and numerical data upon which to base a design; the application of such information in the construction of an ideal piece of apparatus designed to satisfy some human want, where no attention is given to the cost; production of tool-made samples under supposedly commercial conditions; list of tool-made samples and specification of quality requirements that can presumably be met under commercial conditions; and development of production methods. Thus the results of design, development and production are grounded on the initial results of research, but there is always the possibility of assignable causes entering through different sources of material, the human element, and variable conditions which affect the production process; it is, therefore, an advantage to apply tests in order to detect lack of control and then weed out the assignable causes of variability as they occur, and methods are given to achieve this end.

This is a thought-provoking book on a subject that is comparatively new, and as it stresses five economic advantages obtainable through statistical control of quality of manufactured products, it should make a special appeal to all those who are striving to maintain the quality of their products within very small limits of a standard they have set up. It is admirably conceived and well written, the text being supported by tables, diagrams and illustrations, which make it of absorbing interest. In all, there are over 500 pages, including appendices and a bibliography.

By W. A. SHEWHART, Ph.D. Can be obtained from Macmillan and Co., Ltd., St. Martin Street, London. Price, 30s. net.

Praktische Grosszahl-Forschung.

IT IS a typical feature of our time that it has produced an infinity of publications on waste, on possible defective work, and on testing methods, but we know of none indicating ways for applying the various methods to the removal of the causes of defective work with a view to arriving at an economic production of goods which really suit their purpose. A simple means for improving the manufacture and for producing goods of higher quality, and one applicable without the use of expensive equipment, is offered by practical statistical analysis ("Praktische Grosszahl-forschung"). The present book shows how this method is applied, and where it can be applied to advantage.

The object of the book is to help the small manufacturer and tradesman, the chemist, the works and designing engineer, as well as the manager of a large concern, and the wholesale merchant, by showing him a new method of arriving, by merely combining in a suitable way, and analysing data furnished by his establishment, at working rules adapted to his own plant, which are qualified immediately to bring about an increase in the sales, an improvement in quality, and a reduction of waste. The author avers that, in his own field of work, he has not met with any problem concerning the improvement of quality and reduction of waste yet that could not be solved with the aid of the statistical method.

The book is the direct outcome of practical experience. Everywhere experience is given preference over theory. Again and again, the methods described by the author surprise us by their simplicity. Mathematical deductions and complicated calculations are avoided in favour of diagrammatic representation. Altogether new is the method of systematically developing faultless and high-quality products from works which previously had to reckon with high percentages of waste. The axiom that valuable knowledge is gained especially readily from a comprehensive compilation of individual experiences is confirmed by an abundant number of examples taken from the most diversified fields of application ranging from a retail business to the organisation of a large steel concern.

This book ought to be read by all who are earnestly endeavouring to improve the working of their business or factory, or the quality of their products. He who has read it is sure to call for the old records of his firm, and by extracting the requisite figures and analysing them will see what valuable and profitable conclusions he is able to draw, even from such incomplete material.

By DR.-ING. K. DAEVES, Berlin, 1933. Publisher, VDI-Verlag G.m.b.H., Berlin, N.W. 7, Dorotheenstr 40. 132 pages with 58 diagrams and 13 numerical tables. Half-cloth, price, 7·20 marks (VDI-members, 6·50 marks).

Refined Pig Irons:

Their influence on the production of High-Duty Iron Castings

By J. E. Hurst

"DURING recent years remarkable developments have taken place in connection with the treatment and composition of cast iron, so that this material has assumed an entirely new significance in the eyes of the machine designer. As in the case of steel, there is now available a wide range of alloy irons possessing special properties that render them suitable for particular applications." These are the opening sentences from a leading article in a recent issue of a contemporary journal, *Machinery*, and as such are of special significance to all interested in the metallurgy of cast iron in that they indicate an appreciation and a realisation of the progress and value of the important advances made in this field. Refining processes and refined pig irons have played an essential part in making possible this progress, and it is easily perceived from the direction in which these developments are tending that the economic importance of refined pig irons will be still greater in the production of cast irons possessing special properties for particular applications.

the manufacture of chilled castings, the leading refiners are able to produce irons of specific chilling characteristics. In fact, in this direction the properties of cold-blast irons, which have so long occupied a pre-eminent position in the production of chilled castings, have been reinvestigated, and many of the differences between cold-blast irons and refined irons of the ordinary type have been elucidated. This has enabled the manufacturer of refined iron to devise methods of exactly duplicating the properties of the leading cold-blast irons, which has been done in the blended all-mine refined irons now available. This achievement is of double importance, for in addition to providing a means of duplicating the properties of cold-blast irons with consistent regularity, it serves to illustrate some of the methods adopted by the leading manufacturers of refined irons in the production of such irons of special properties. In this case the investigation commenced with a careful examination of the properties of various cold-blast irons of recognised type, and their comparison with refined iron of

TABLE I.

	Pig Iron.	Composition.					Chill Test Details.							Mechanical Properties.						
		Total Carbon	Silicon	Mn.	S.	P.	Chill Depth. In.	Chill Type.	Scler.	Brin.	Firth.	Mottle Depth. In.	Type Back.	Tens Tons/Sq. In.	Mod. Rupture.	En Value.	Resil.	Limit Property.	Perm. Set.	Type of Curve.
1	Valley	3·71	0·52	0·39	0·125	0·37	⅜	Bright	63	465	522	1¼	Med. open Grey	25·4	40·5	17·0	28·2	12·0	6·8	Good
2	Swedish	3·16	1·32	0·28	0·050	0·18	⅛	Dull	58/60	440	488	⅝	Air chill. Close grey	22·6	36·2	16·8	29·8	13·0	8·8	Good
3	Grazebrook	3·00	0·83	0·42	0·139	0·43	⅜	Norm.	60	420	460	1⅛	Close grey	25·9	41·5	17·1	29·8	13·0	8·8	Good
4	Dudleys	3·49	0·83	0·59	0·105	0·48	1/16	Med. Bright	60	433	481	¾	Med. open Grey	16·8	26·7	17·5	20·6	—	9·5	Poor
5	Charcoal	3·99	0·91	0·41	0·016	0·16	Trace	Bright	—	221	237	Nil	Very open Grey	20·2	32·2	16·9	21·6	—	15·6	Mod.
6	Ordinary refined No. 8070.	3·11	0·75	0·30	0·071	0·39	⅛	Norm.	58/60	400	428	1	Close grey	18·6	29·8	16·6	15·5	—	2·5	Poor
7	Refined iron substitute, 7B/9.	3·43	0·87	0·54	0·096	0·42	1/16	Dull	60/65	465	526	⅞	Med. grey	19·6	31·4	17·9	20·8	12·0	5·4	Good
8	Blended all mine, refined 6B/2.	3·71	1·12	0·41	0·068	0·49	⅛	Bright	55/60	480	551	Nil	Open grey	26·8	43·0	17·8	30·8	14·0	7·5	Good
9	Blended all mine, refined 8411.	3·82	0·66	0·45	0·08	0·44	¼	Very Bright	70	495	575	⅝	Open grey	25·9	41·5	18·0	29·75	14·0	12·4	Good
10	No. 5 charcoal, with 60% roll scrap.	3·00	0·66	0·25	0·110	0·35	1	Med. Bright	60	440	488	1 11/16	Close grey Air chill	25·9	41·5	17·2	25·4	—	14·8	Mod.
11	No. 7 refined iron substitute 7B/9, with 33% roll scrap.	3·11	0·69	0·47	0·128	0·37	1	Dull	50/55	440	479	2	Med. grey Air chill	20·1	32·2	18·0	19·5	12·0	6·6	Good
12	Blended all mine, 6B/2 50% roll scrap.	3·27	0·79	0·35	0·126	0·45	1	Dull	60/62	470	510	2¾	Close grey Air chill	25·8	41·3	18·1	31·5	14·0	7·8	Good

The leading manufacturers of refined irons, by the utilisation of various processes of melting, superheating, and after-treatment of molten metal, by their own intensive research into the characteristics of irons and the effects of blending and modifying processes on the mechanical and structural properties, have been enabled to supply to the ironfounder raw materials possessing specific properties, which can be maintained accurate and uniform. For example, in those irons which come within the category of refined cylinder irons, there are manufactured irons having superior strength properties, irons having intrinsically high moduli of elasticity, irons having specific magnetic permeability characteristics, irons having specific structural characteristics, inoculated and fine graphite irons, all these in addition to such specific requirements as low total carbon, high total carbon, various guaranteed compositions, degasified irons, etc. In the production of refined irons for

an ordinary type. Some of the results obtained are summarised in the first part of Table I. An examination of these results shows quite a number of differences between the recognised cold-blast irons and the specimen of ordinary refined iron. The difference in strength properties, particularly the resilience value, will be noted. Attempts were made to improve these properties by blending together materials which were found by previous experiment to possess suitable properties. Some of the results obtained are given in the second part of the table. Item 7, the refined iron substitute, shows improved properties of an intermediate character, whilst the blended all-mine refined irons described in items 8 and 9 show that the properties of the cold-blast irons have been completely and successfully duplicated. The last section of the table is devoted to a comparison of the properties after remelting and admixture with roll scrap following upon the practice

commonly adopted in roll foundries and in the manufacture of chilled castings. These further results demonstrate clearly that the properties of the blended refined material are retained, and compare equally with those of a roll mixture in common use, based upon the use of charcoal iron.

The importance of these developments lies not only in the duplication of the properties of cold-blast pig irons by refining methods, but in the fact that greater control of the nature, occurrence, and uniformity of these properties is rendered possible, a circumstance which must tend ultimately to a higher standard of quality in the final castings. This example serves to demonstrate one of the most important aspects of the economic value of refined irons to the high-duty iron-foundry industry. This, of course, lies in the extreme flexibility of the refining processes, coupled with the facility for the exercise of the strictest possible control over all those considerations of composition, physical and mechanical characteristics, which are necessary in high-duty irons. Nowhere is this more apparent than in the new application of refining processes to the production of alloy pig irons. The production of various types of alloy cast-iron castings is a rapidly growing section of the ironfounding industry. Chromium and nickel-chromium cast irons are finding use in the production of heat resisting and wear resisting castings suitable for heat-treatment by hardening and tempering. Nickel and other alloy additions are attracting attention in the production of high-strength and martensitic castings. The production of austenitic cast irons having specific corrosion-resisting, heat-resisting, and specially high thermal expansibility and non-magnetic properties, is now an important section of the ironfounding industry. In many of these alloy cast irons the alloy additions in substantial quantities are essential, and it is hardly necessary to set out in detail all the reasons, both technical and economic, which render the strictest accuracy of composition essential to the successful production of these cast irons. The value of refined alloy pig irons as an aid to the successful production of alloy cast irons is best exemplified by a description of the refined chromium alloy pig irons, specifically designed for the addition of chromium, one of the most important of the special alloy additions. The ferro-chromium alloys are the most common source of chromium for alloying purposes, and such alloys are available from the "carbon-free" varieties up to those containing 8 to 10% of carbon. The melting point of pure chromium is high—viz., 1,615° C.—as compared with cast iron at 1,150° C. The ferro-chromium alloys are likewise very refractory, and in the high-chromium alloys containing 6 to 8% carbon, there exist compounds which only melt completely above temperatures of 1,600° to 1,700° C. These considerations entirely rule out the possibility of adding chromium to the necessary degree of accuracy, as ladle additions. Even in the cupola there is considerable difficulty in ensuring the complete melting of ferro-chromes apart from the potentially high losses and irregularities invariably associated with the addition of elements in concentrated form in this manner. The use of refined chromium-alloy pig irons provides the most satisfactory method of making accurate additions of chromium to cupola mixtures. A typical range of refined chromium alloy pig irons is given below :—

TABLE II.

Brand.	Total Carbon. %.	Silicon, %.	Sulphur, %.	Phosphorus %.	Manganese, %.	Chromium, %.
C.D.	2·9 to 3·1	To suit requirements.	0·08 Max.	To suit requirements.	To suit requirements.	2·2 to 2·5
C.E.	2·9 to 3·1		0·08 Max.			2·75 to 3·0
C.F.	3·5 to 3·75		0·08 Max.			7·75 to 8·0

The composition of the brand C.F. is approximately that of the ternary eutectic of the iron-carbon-chromium series, which, in accordance with von Vegesack's determination, lies at 8.0% Cr, 3·6% C, 88·4% Fe, with a melting point of 1,050° C., somewhat lower than that of high-duty cast iron. The addition of approximately 17 lb. to 20 lb. of this pig iron per cwt. of metal provides an addition of 1% chromium. Incidentally, these high alloy content pig irons are produced in the form of small sand-cast or machine-cast pigs to facilitate accurate weighing of small quantities, and also their use in crucible and hearth-type furnaces. The appearance of typical fractures of refined chromium irons C.D., 2·5% Cr, and C.F. 8·0 Cr, are illustrated in Figs. 1 and 2.

Fig. 1.—Refined Chromium Alloy Pig Iron. C.D. Chromium 2·5 %.

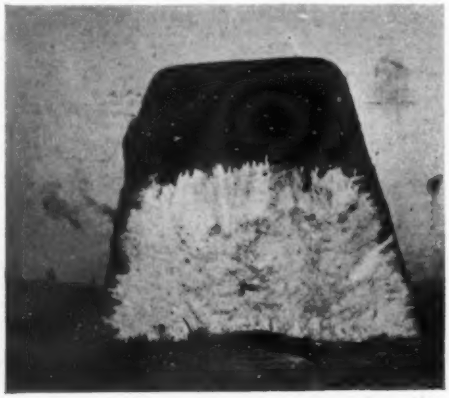


Fig. 2. Refined Chromium Alloy Pig Iron. C.F. Chromium 8·0 %

For the addition of others of the alloying elements, such as nickel, molybdenum, vanadium, silicon, etc., similar rich refined alloy pig irons are available, and their utility and economic value are based on exactly the same considerations. Refined alloy pig irons containing chromium and nickel, either singly or conjointly in smaller quantities, are available for direct use in the production of the various alloy cast-iron specifications. The refining processes have also been adapted for the production of special alloy cast irons in ingot form of such compositions that on remelting either in the cupola or crucible the correct composition is obtained. These irons are invaluable to the founder in the production of austenitic cast irons of the Nicrosilal and Ni-resist type, in enabling their production to correct specification both in regard to chemical composition and structural characteristics being ensured.

Sufficient has been written to demonstrate the importance of refining processes and refined irons in the production of high-duty iron castings, and there can be no doubt that the rapid growth in the development of such cast irons during recent years has been assisted in a very large measure by refined and refined alloy pig irons.

NOTES ON THE COPPER-RICH ALLOYS.

By Eng.-Com. (Retd.) H. C. Anstey, M.Inst.C.E., M.Inst.M.

The development of copper alloys is briefly reviewed and the effect of small percentages of other elements discussed. Metallurgical science has not yet overcome methods involving trial and error, but the author suggests that it may be possible ultimately to determine mathematically the subsequent conditions when two or more systems combine.

OF the making of many alloys there is no end, as Solomon might have written had he been an engineer or metallurgist as well as a philosopher. The ancients knew the working properties of copper as found in its native state. They also knew that the smelting of ores from certain districts produced a metal hard enough to be used for implements, or which could be cast into ornamental shapes. Many of these ancient bronzes have been analysed. They vary widely in composition, and seem to indicate the stages of development to have been, first, the smelting of an ore of composite character from one district, and then as supplies in the district became worked out the search for ores in other districts, with perhaps the mixing of them in various proportions.

Such haphazard methods of alloying existed until well after the birth of modern chemical science. There exists a minute book of the Cheadle Brass Co., of the early years of the nineteenth century, in which it is recorded that the manager of their mill was authorised to "import" a certain quantity of calamine from Wales for the making of brass, so that evidently spelter as we now know it was not available, though the extraction of zinc from its ores appears to have been known in China about a thousand years ago.

As the result of progress in chemical science new methods of extraction of metals from their ores were evolved and the number of metals enlarged by new discoveries, and, ultimately, the elements themselves were shown to fall into a systematic plan where their characteristics repeat themselves in a periodic series. The importance of these steps to those who have to deal with non-ferrous materials is obvious. It is a far cry from the metallurgy of Ur of the Chaldees, with its smelting of mixed ores, some perhaps from the Caucasus, some perhaps from Arabia, to the modern metallurgy, with the smelting and refining of each metal separately, obtaining in each case a high degree of purity not possible formerly.

The use of the electric current for the refining of metals by deposition was an important advance and opened up new possibilities not only from the results to be obtained from alloys formed from pure materials, but also enabling impure ores to be refined which otherwise would be difficult or impossible to treat satisfactorily by fire refining, thus extending the ore resources of the world. As purer materials became available it was natural that the question of the effect of impurities should assume prominence, and a great deal of research work has been done, and is still being done in that sphere. The question is not only what harmful effects may be produced by the presence of other elements, say in copper in small proportions, but also whether the presence of such small quantities can be made to serve a useful purpose.

Now, obviously, to determine such points we must have a pure material as a standard of reference, or to know that the presence of other elements is so small as to make no difference. The physicist here comes to our aid with the spectroscope. Though spectographic analysis has not yet developed as far as it is expected that it will do, it enables the detection of traces which would be difficult to find by ordinary analysis.

Copper combines with certain other metals like tin and zinc to form solid solutions, while others, like lead, though they may be found in the copper, are there uncombined. It is the presence of these latter that gives rise probably to the greatest manufacturing difficulties. A trace of lead in pure copper that is to be used as such has no obvious disadvantages. It was frequently used by refiners to bring copper up to pitch. It does not lower the electrical conductivity to any appreciable extent, it does not interfere with the working properties of the copper, and the mechanical results obtainable are not sensibly different for copper with lead absent. If, however, lead is present in a bronze (by which is meant an alloy of copper and tin only) the effect on the working properties of the alloy is serious. The lower range of tin bronzes, up to 1% tin, which, with pure materials, can be worked in the hot condition, become hot short when lead is present in quite a small percentage.

In the brasses there used to be a definite distinction between what were called hot-working and cold-working. Electrolytic spelter has made that division an arbitrary one. All the brass alloys can be described as hot-working providing that pure materials, that is, electrolytic copper and spelter, are used. The expense of the more costly materials is not always justified, but, on the other hand, there are cases when the greater ease of working with the pure material may offset the difference in the value of the metals.

The effect of small additions of other elements to copper has received a good deal of attention. Silver adds to the hardness in the worked condition, and does not appreciably affect the conductivity. It has the valuable property of raising the annealing temperature, making copper containing it suitable for work where hardness has to be retained, though the metal has to be soldered or baked. The effect of the deoxidising elements like phosphorus and silicon is also well known. They add to the mechanical properties of the copper, but rapidly reduce its electrical conductivity.

It is a matter of common experience that the properties of an alloy are generally widely different from those of its constituents, but there are two figures which vary very little in all the rich copper alloys—the modulus of elasticity and the coefficient of expansion. If one considers the stress strain curve of one of these alloys a possible explanation is that the modulus of elasticity is derived from the initial shape of the curve, which illustrates the elastic stage, while properties like ultimate tensile are represented by the later stages corresponding to the "plastic" state. The coefficient of expansion is probably also connected with the elastic state. Consequently, where the copper predominates in an alloy, it is not unreasonable that these two figures should closely follow those of pure copper. This feature has an important practical application for aerial lines formed of stranded conductor, where, to increase the strength, part of the conductor is of bronze or some other copper alloy. Such a line is for all practical purposes of a homogeneous

construction, and differences of temperature and strain will affect all the wires equally.

One point of interest may be noted on the effect of additions of other metals on the electrical conductivity of copper. The effect has been studied by various investigators and the characteristic curves drawn giving the relation between conductivity and the amount of added elements. Though the slopes of these curves vary greatly, those of metals like zinc and tin, which form solid solutions with copper, begin as straight lines. If additions of more than one of these elements are made the resultant effect on conductivity is found by multiplying the conductivities of each addition taken separately. For example, 1% of added zinc reduces the conductivity of copper to 83%. One-half per cent. of tin reduces the conductivity to 68%. The effect of adding both will be to reduce the conductivity to (83×68) % i.e., 56·4%. The important proviso must be noted that this calculation will only be correct provided that the additions made are within the limits of proportionality.

Mention has been made of the effect of lead on the working properties of bronze. Where castings only are required lead is frequently added in fair percentages, to increase corrosion-resistance properties. It has been noted by some investigators that in certain cases pure materials resist corrosion less than those containing impurities, but it would be wrong to draw any general conclusion from these detached observations. The question of corrosion is too large to enter into in these short notes, but it may be noted that the alloys of copper and tin, which, if they are to be worked satisfactorily, must be made of pure materials, have a very good all-round resistance to corrosion.

These bronzes are usually called phosphor bronze because of the use of phosphorus as a deoxidiser. Formerly, a fair percentage of this element, sometimes ½%, or even more, was considered essential to ensure sound castings. Phosphorus will mask the effect of some of the minor impurities, but if only pure materials are used and care is taken quite a small amount is all that is required to ensure the necessary fluidity for casting, and the range of workability of the material is extended.

As an engineering material this has many applications. It is particularly suitable for pump rods and the impeller shafts of centrifugal pumps. It is largely used as valve-guides for internal-combustion engines, and was used for the reinforcing wires for the electric cables crossing the River Thames. There are other alloys that would be better for individual conditions, but it is doubtful whether there is one which possesses such a range of good qualities as to make it suitable for so wide an application. There is perhaps something in ancestry, and the family tree of bronze goes back for 5,000 years at least.

Another copper-rich alloy, or rather group of alloys, which are receiving increasing attention for engineering purposes are the aluminium bronzes.

Aluminium bronze has been known for more than half a century, but its practical use is of much more recent date. The melting point of aluminium is some 400° C. below that of copper, and the ease with which aluminium oxidises at a high temperature makes the casting operation of aluminium bronze much less easy than with most other alloys. Inclusions of the oxide of aluminium are fatal to its working properties, but by great care in preparing the molten metal and pouring by a non-turbulent method, such as the Durville, sound castings which present no trouble in working can be obtained. The alloy with 4% to 5% of aluminium has a golden colour, and has been much used as an imitation of 18-carat gold. This proportion of aluminium does not confer sufficiently increased mechanical properties to make it worth while as an engineering material. For drawing into wire, 6½% of aluminium is a suitable proportion, and for forgings, from 8½% to 10½%. Aluminium bronze can be heat-treated by quenching and tempering, but the aluminium should not be less than 9¾% if this operation is required. On the other hand, if any cold working is to be done, the aluminium should preferably be not more than 9%, although even the 10% alloy is capable, with care, of receiving a limited amount of cold working.

It has been pointed out that though the properties of an alloy vary widely from those of its constituents, certain characteristics of the parent elements are apt to be reproduced in the offspring. In the case of aluminium bronze, the weak mechanical properties of aluminium and copper are reproduced in the aluminium bronze as a low-yield point. (Incidentally, aluminium bronze in the hard-worked condition inherits the dislike of aluminium for strong alkalis). This low-yield point makes it unsatisfactory for certain purposes, so that the "straight" aluminium bronzes (that is, copper and aluminium only) have not the same application as the modified aluminium bronzes where other metals are added to correct this defect. Nickel and iron are those mostly used, though manganese is also employed. Up to 5% or 6% of both nickel and iron have been used, and tensile strengths of over 50 tons realised, but such large additions tend to increase the difficulties of hot working, and it is certain that comparable mechanical properties can be obtained with lower additions. For example, with a 10% aluminium bronze " modified " by the addition of 2% of nickel and 1% of iron, a yield point of 30 tons with an ultimate strength of 43 tons and an elongation of 21% has been obtained. On a small section 47 tons tensile has been realised. A non-ferrous alloy with these properties has obvious applications in engineering in cases where the use of steel with its tendency to rust has practical disadvantages. For example, brass or gunmetal nuts have often been used in conjunction with steel bolts where there is a likelihood of a steel nut seizing owing to the conditions under which the bolt is used, as in the interior of a steam cylinder. Where a high-tensile steel is used there is a great disparity between the strength of the bolt and that of the nut unless something stronger is available than cast material.

Another useful feature of the modified aluminium bronzes is that they retain their strength reasonably well at elevated temperatures. The alloy mentioned above, which at atmospheric temperature had a tensile of 47 tons per square inch, still had a tensile strength of 30 tons at 350° C., which would make it suitable for employment under ordinary conditions with superheated steam, say of 300 lb. pressure and 200° F. superheat.

The two classes of alloys already mentioned—that is, the tin bronzes and the aluminium bronzes—may be taken as typical of the response to the demand for better materials in the copper-rich alloys, but they do not exhaust all the possibilities. Beryllium-copper alloys are more striking in their characteristics than the aluminium bronzes, and only the high cost of beryllium prevents their more rapid development.

In considering all these possibilities it must be confessed that in spite of the enormous strides made in metallurgical science we are still too largely dependent on the methods of trial and error. It has been shown how in certain simple cases it is possible to predict the electrical conductivity of a copper alloy, but no such prediction is possible as to its mechanical properties, though much help can be obtained from the equilibrium diagrams which have been worked out for a number of alloys, in determining such properties as the range of hot and cold working. Perhaps the physicist could help. If, as he asserts, the atom is a solar system in miniature, it should be possible to determine mathematically the subsequent conditions when two or more systems combine. If it is found possible eventually to make such predictions a great deal of unnecessary labour will be avoided, and while it will open-up new possibilities, it will tend to diminish rather than increase the number of non-ferrous alloys. " 'Tis a consummation devoutly to be wished." Most manufacturers will agree that there are far too many alloys already.

The British Industries Fair

A survey of outstanding metallurgical features.

THE national effort to display the resources of British industry, organised by the Department of Overseas Trade, shows every indication of being more impressive than ever. All sections of the British Industries Fair at Olympia and the White City in London and at Castle Bromwich show substantial increases in both the area occupied by exhibits and in the number of firms exhibiting. Although not yet fully representative of the full resources of British industry, the exhibits in London and Birmingham will be more comprehensive and on a larger scale than any previous national exhibition. Its primary object is to bring together as many potential buyers as possible, and a corresponding body of British manufacturers ready and willing to supply their needs, and, in view of the slight improvement in trade, the prospects of the effort being successful are exceedingly bright.

The Fair, which opens officially on February 20 and remains open until March 3, will not only contain a record display of an endless variety of products, but will indicate the efforts made during the past year to develop new industries and to improve the quality and finish of materials and products. The use of modern machinery, coupled with improved technique, in which the scientists and the manufacturer have collaborated, enables British industries to compare favourably with any other country in regard to quality, workmanship, and price of products, and a careful inspection of the exhibits at this Exhibition will emphasise the degree of progress that has been effected. To all visitors the whole display will convey some idea of the enormous potentialities of the British Empire, and will, in a measure, explain why British products are highly esteemed in every civilised country.

It is not possible to give even a cursory survey of the whole Exhibition, and in our reference here we shall deal with some outstanding exhibits at both Olympia and Birmingham that have a direct bearing upon ferrous and non-ferrous production, in semi-finished and finished forms, together with the developments and products of those industries closely associated as users of these materials. Various forms of plant and equipment in which recent developments have been incorporated will also be discussed,

Fig. 1.—Blackheart malleable cast specimens after testing.

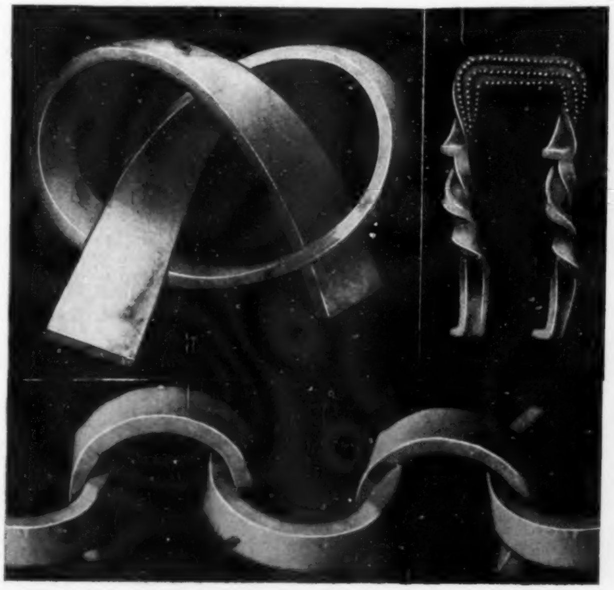


Fig. 2.—Cold saw, with segmental teeth, in action.

and an effort made to direct the visitor, with limited time at his disposal, to those exhibits which have outstanding qualities.

In the metallurgical section attention is particularly directed to the increasing application of the more recent developments in ferrous and non-ferrous materials, especially to heat- and corrosion-resisting metals, but it must be borne in mind that the materials which form the basis of production in the ferrous and non-ferrous industries have also been improved.

In blast-furnace practice, for instance, efforts have been concentrated on increased quality of product, and plants have been either modified or entirely reconstructed to facilitate production, in keeping with advances in research, on an economic level. Valuable investigations on the factors that influence the quality of steel have been instrumental in improving the wide range of finished and semi-finished materials produced from steel ingots. Even pig iron, generally regarded as the crudest form of iron, is now available in a wide range of qualities from common pig in its various grades to various grades of special refined irons and refined alloy irons.

The greater emphasis on analysis has caused several manufacturers to operate so that analyses of similar grades of pig iron are produced within very close limits. The all-mine refined pig irons of the United Steel Companies, samples of which will be on view, are sold only to analysis. Many displays of pig iron showing typical fractures of varying grades, will prove of special interest to foundrymen. In addition to the United Steel Companies' display, foundrymen should make a point of seeing Stewarts and Lloyds' display, and also that of the Staveley Coal and Iron Co., Ltd.

Despite keen competition, malleable-iron casting manufacturers are maintaining their markets; it has only been possible, however, by adopting progressive policies in

which the results of research have been put into practice. Notable examples of work of this character will be shown by Thomas L. Hale (Tipton), Ltd., Leys Malleable Castings Co., Ltd., Court Works, Ltd., and Coventry Malleable and Aluminium, Ltd. Both whiteheart and blackheart castings will be exhibited. In Fig. 1 is shown a number of tests to which Hale's blackheart castings have been submitted. Considerable attention is given to the selection of material, melting, and heat-treatment, and complete success is only possible when these are scientifically arranged and controlled. Evidence of this control will be observed in the

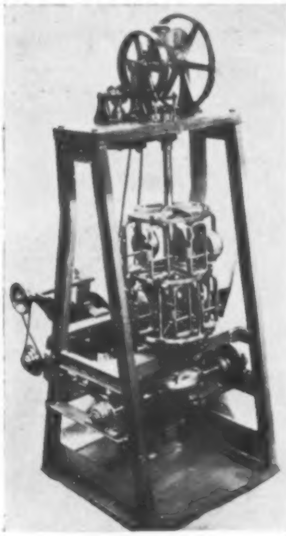


Fig. 3.—Wire-stranding machine.

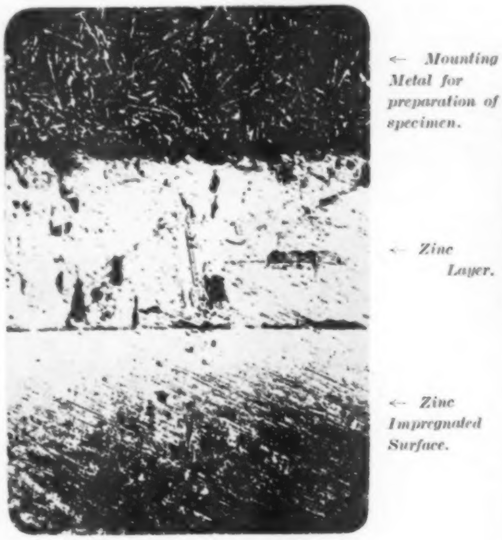


Fig. 4.—Micrograph of Sherardized surface.

quality of the exhibits, the term being applied to the regular mechanical properties of the material as well as to the finish of the castings.

The display of rolled sections, plates, sheet, and wire, in ordinary carbon and mild steel, in a variety of shapes and thicknesses, will show how extensively manufacturers are meeting the needs of producers. But it is likely that the development of alloy steels and their increasing application will attract more attention, particularly some of the exhibits of stainless steel, with their mirror-like finish. Other steels that have been developed for specific purposes, however, will not be overlooked. Visitors needing materials

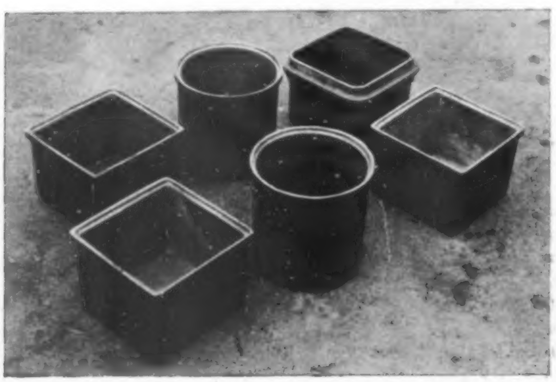


Fig. 5.—Annealing pots in "Chromite."

which will give increased service to their manufactures under existing conditions of service or withstand more exacting duties without modifications in design, will find much to interest them. Comprehensive displays will, in many cases make selection difficult, but the following should be inspected: Baldwins, Ltd.; British Rolling Mills, Ltd.; Cargo Fleet Iron Co., Ltd.; Thos. Firth and John Brown, Ltd.; Hall and Pickles, Ltd.; Portsmouth Steel Co., Ltd.; Metal Sections, Ltd.; Sanderson Bros. and Newbould, Ltd.; Walter Somers, Ltd.; Staveley Coal and Iron Co., Ltd.; Stewarts and Lloyds, Ltd.; and United Steel Companies, Ltd.

The application of alloying elements in steels, for a large number of branches of engineering, will be demonstrated by a number of exhibits on the stand of High Speed Steel Alloys, Ltd. The increasing application of molybdenum alloy steels will be shown by several examples, and a full range of the products of this firm will be on view. The

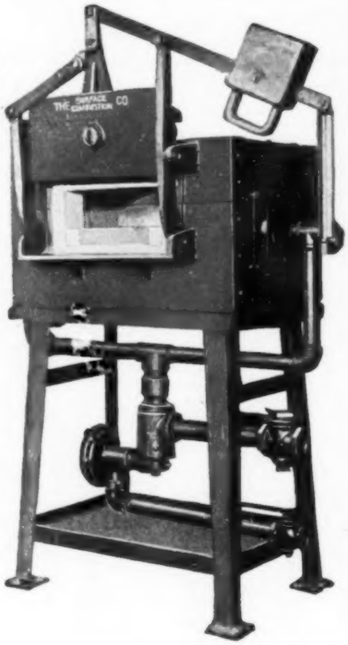


Fig. 6.—An oven furnace for temperatures ranging between 600° and 1,350° C.

latter consist of pure metals and alloys of tungsten, vanadium, molybdenum, chromium, manganese, titanium, etc.

An outstanding exhibit which shows the remarkable cutting ability of high-speed steel is a segmental cold saw. This is a product of Sanderson Brothers and Newbould Ltd. The teeth in this type of saw are made in segments, each segment consisting of two, three, or four teeth, according to the pitch of tooth required. The illustration, Fig. 2, shows one of these cold saws in service. It is particularly interesting to note the amount of work these saws can accomplish; the following extraordinary figures indicate their fast-cutting capacity. A 26-in. diameter saw has so far cut, without resharpening: 111 pieces of steel rail (analysis 0·97% mm. and 0·46% C.) at an average speed of 45 secs. per cut; 153 rings, section 3 in. × $\frac{3}{4}$ in.; 12 channels, 5 in. × 3 in. × $\frac{3}{8}$ in.; 12 channels, 3 in. × 3 in. × $\frac{1}{2}$ in.; 2 mild steel bars, $1\frac{1}{2}$ in. diameter; 1 steel bar, 6 in. diameter, of 0·45% C. in 1 min. 58 secs.; after which the saw was still working.

In addition to high-speed steels in varying grades which will be exhibited by many of the firms already mentioned, the comprehensive range of tools tipped with Wimet brand cutting metal will create much interest. A. C. Wickman, Ltd., are showing tools of this kind, which include turning and boring tools, twist drills, reamers, milling cutters, etc., and there will be several grades of Wimet brand tips for dealing with various classes of metals. In addition, Spedia lapping wheels will be exhibited, which have recently been developed for the final lapping of hard materials where an exceptionally fine finish is required.

The use of weldless steel tube is increasing, and so many different applications will be demonstrated that it is impossible to enumerate them here, but examples shown

by Accles and Pollock, Ltd., are applicable to a great number of manufacturing industries. Amongst these exhibits will be seen aircraft tubular construction, stainless steel tubes, and their manipulation; in addition, there will be special section tubes in all sizes from 0·019 in. O/D to 5 in. O/D. The Britannia Tube Co. will also have a very comprehensive exhibit, showing various forms of tube in mild steel and stainless steel.

Messrs. G. A. Harvey and Co. (London) Ltd. exhibit an astonishing range and variety of products in sheet metal and steel plate. One of the recent developments of this firm has been the manufacture of steel equipment for offices and works, and various examples will be shown. Perforated metals and woven wire are of interest to many industries, so that their use in the production of equipment for screening, grading, sifting, and filtering materials of such diverse characters as coal, ore, sand, cereals, food products, fine chemicals, etc., gives them a wide application. An attractive display of perforated plate and wire cloth will also be shown by Thos. Locker and Co., Ltd.

A range of Telcon electric resistance materials is shown. These include Pyromic, the 80/20 nickel-chromium alloy from which the elements for Wild-Barfield furnaces are made, Calomic, a ternary alloy containing nickel, iron, and chrome in the proportions 65 : 20 : 15; and Telconstan, a copper-nickel alloy, which has a negligible temperature coefficient of resistance. These alloys, made by the Telegraph Construction and Maintenance Co., Ltd., are distributed by Wild-Barfield Electric Furnaces, Ltd., and will form part of their exhibit.

The non-ferrous metals generally lend themselves to display purposes, and a surprising number of attractive exhibits will give colour to the metallurgical section at Birmingham. Probably the largest is that of Imperial Chemical Industries, Ltd., whose exhibit covers an area of 2,250 sq. ft. The stand has as its main feature a building embodying offices and interviewing rooms in which the uses of non-ferrous metals for decorative effect and utility are demonstrated. Of considerable interest will be coils of strip 24 in. wide, weighing nearly half a ton, the products

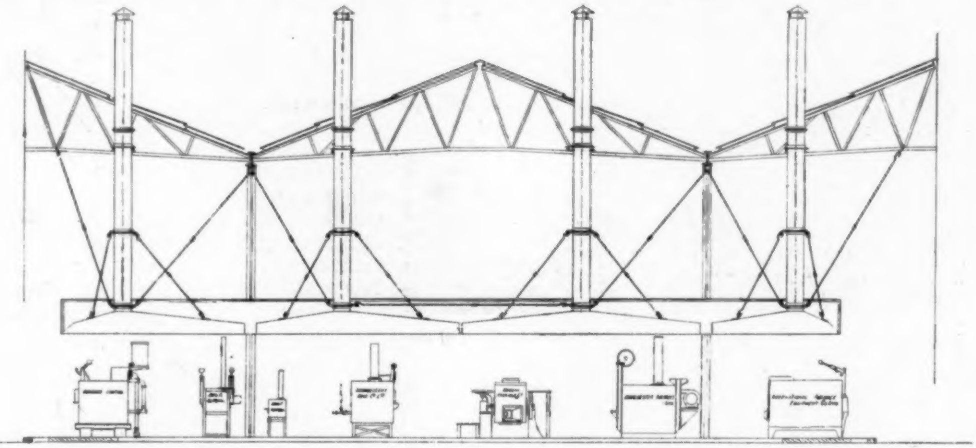


Fig. 7.—A line-drawing of the display by Shell-Mex-B.P., Ltd.

of the new electric mills installed by this company

Of the many exhibits of wire, mention may be made of that manufactured and shown by the Whitecross Co., Ltd. Attention is directed to "Silflex" brand galvanised wire which will not flake or peel even when wrapped round its own diameter. Models will be shown demonstrating the production of galvanised wire from the steel billet, and a stranding machine, Fig. 3, will be displayed which will demonstrate the method employed in laying up wires into strand.

The method of protecting the surfaces of iron and steel articles by "Sherardizing" will be shown by Zinc Alloy Rust Proofing Co., Ltd. This process consists in heat-treating the articles in contact with zinc dust in such a way that an iron-zinc alloy is formed. The process somewhat resembles casehardening, in the sense that a thin surface layer is impregnated with zinc, as is shown in Fig. 4.

Non-Ferrous Metals.

Nickel has contributed considerably to modern progress, and a range of exhibits showing some of the many applications of the metal and its principal alloys will be displayed by the Mond Nickel Co., Ltd. Here will be seen one of the newest developments in the nickel industry, that of nickel-clad steel. The potentialities of this composite material are very great in the construction of plant to resist corrosion, and it will arouse much interest.

Typical examples of alloy iron casting of both low and high nickel content will be displayed, as also will be nickel alloy steels. Other exhibits will include condenser tubes in nickel-copper alloys, plumbing fittings, and telephone relay springs in nickel silver, heat-resisting castings in nickel-chromium alloy (Fig. 5), a thermostat sectioned to show the use of low expansion nickel-iron alloys, and examples of the uses of Monel metal.

Serck Tubes, Ltd., have made remarkable progress in tube extrusion and manufacture. This firm successfully extruded 70/30 brass over ten years ago, and are now in a position to extrude tubing in any alloy in approximately 60 ft. lengths in less than 10 secs. Some illustrations showing the plant at the Birmingham works of this firm are shown in connection with another article in this issue. A wide range of exhibits which include locomotive boiler tubes, condenser tubes, superheater tubes, various forms of copper and brass rod, sheet, and wire, will be shown by the Birmingham Battery and Metal Co., Ltd.

A large assortment of brass and bronze sections from a range numbering many thousands, together with hundreds of stampings, will be exhibited by McKechnie Brothers, Ltd., who are displaying their well-known "Tank" and "MKB" brands of extruded brass, bronze, and white metal rods and sections, solid brass, bronze, and white metal stampings; gunmetal and phosphor bronze, and many other products in which this firm specialise. Sheet, strip, and wire in nickel silver, brass, copper, and other alloys will be shown by Barker and Allen, Ltd. In most cases the exhibits will be bright rolled. Emery Bros., Ltd., are exhibiting their brass stamping strip, which is specially annealed for stamping and forming.

Further development in the application of the light alloys will be indicated by a wide range of exhibits. New problems have been met by new aluminium alloys, and in some cases these have been substituted for the heavier metals with success in numerous directions. Outstanding of these may be mentioned the resistivity to corrosive influences and the continued call for weight reduction without sacrificing the factor of safety. Aluminium alloys are being increasingly employed for architectural work,

shop fittings, etc., because of their attractive appearance and their ability to maintain a high polish for prolonged periods without cleaning. An alloy having equal or superior properties to pure aluminium, from the points of view of weight and resistance to corrosion, combined with increased strength, which extends the possible applications to a wide field, is exhibited by Cindal Metals, Ltd. This is their J551 alloy, which is claimed to be the most resistant to sea-water and atmospheric conditions of any aluminium alloy yet produced.

At the time of writing information regarding all the non-ferrous exhibits is not available, but visitors should see the displays by Delta Metal Co., Ltd., Hot Pressed Products (1928), Ltd., T. J. Priestman, and Diecastings, Ltd., to mention a few, in order to grasp the extent of the field covered.

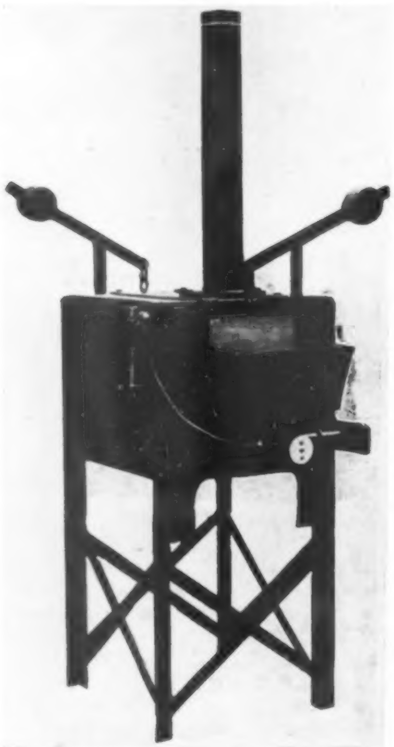


Fig. 8.—Furnace for heating billets for press work.

Heat-Treatment and Melting Furnaces.

A number of melting and heat-treatment furnaces will be displayed in conjunction with the exhibits of the British Commercial Gas Association and the Birmingham Corporation Gas Department. These include several designs by British Furnaces, Ltd., one being a soft metal melting furnace for melting lead, zinc, tin, aluminium, and other soft metals. A feature of these furnaces is the surface combustion air-gas proportioner, which at all times mixes the gas and air in the correct proportions for complete and perfect combustion, without need for adjustment by the operator. Only one valve is used, and automatic temperature is readily obtained by means of a thermostat.

An oven furnace designed for operation over a wide range of temperature from 600° C. to 1,350° C. is also shown by this firm. This type of furnace, shown in Fig. 6, is used for a great variety of work, especially for the heat-treatment of both carbon tool steel and high-speed steel. For work requiring medium temperatures, like carbon steel, burner equipment allowing a controllable working temperature range of 600° C. to 1,100° C. is supplied.

Several furnaces by Lucas Furnaces, Ltd., will be on view which will embrace the latest developments. A small gas-fired natural-draught furnace will demonstrate how work can be treated on the continuous principle, free from distortion and scale. The components to be treated are placed into containers to facilitate handling, and introduced from a charging table through the heating chamber, when they are gradually brought up to the required temperature, and if quenching is desired this is done direct without the work coming into contact with the outside atmosphere. Such desirable conditions are made possible by a patent design which embodies a highly efficient metal recuperator and a most effective gas-screen arrangement at the front

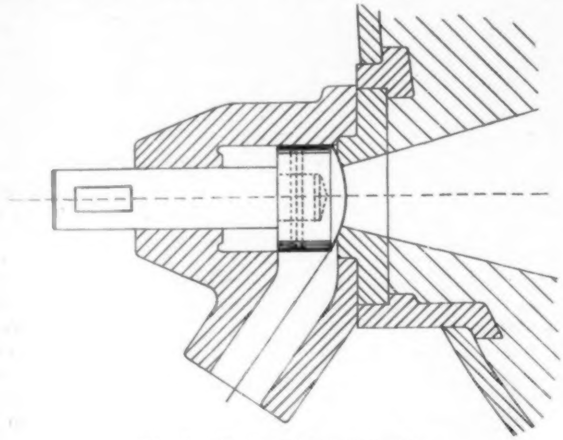


Fig. 9.—Design of tapping valve.

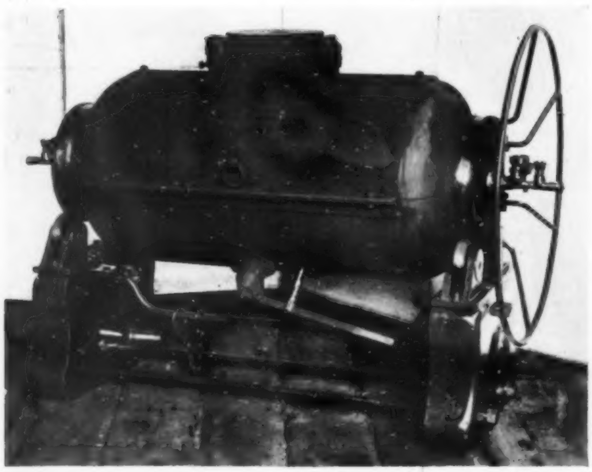


Fig. 10.—Semi-rotary melting furnace.

of the chamber, which assure evenness of temperature with correct atmosphere under working conditions at a low cost of operation. A high-speed steel hardening furnace, in which steel can be treated quite free from scale, is another exhibit.

All Lucas furnaces have the metal recuperator for utilising the waste heat for preheating the air necessary for intensifying combustion, together with the gas screen arrangement at the front of the chamber, which effectively prevents air entering the chamber when the door is open.

Particular attention should be given to the furnace exhibited by the Incandescent Gas Co., Ltd., while mention must be made of the new designs of muffle furnaces exhibited by the Selas Gas and Engineering Co., Ltd., which have many interesting features. The smaller sizes are suitable for many kinds of laboratory and experimental work, such as testing of materials at high temperatures, assaying, metal heat-treatments, enamel work, analytical work, and many other purposes. The larger sizes are applicable to productive work as well as for experiments

and tests on a bigger scale than is possible with the small furnaces. Several types of burner and injectors will also be exhibited, suitable for town's gas, coke-oven gas, clean producer gas, and other industrial gases.

The use of town's gas in industry is extending rapidly, and some idea of its numerous applications will be obtained from an examination of the extensive display of gas apparatus on this stand of interest to the manufacturer and the factory owner.

Considerable progress has been made during recent years in the applications of oil-fuel, and the Shell Mex and B.P. display will attract much attention. The area occupied will be larger and the display more comprehensive than last year. As will be seen by Fig. 7, many oil-fired furnaces will be on view; in the majority of instances these will be in operation, and visitors will have an opportunity of determining the effectiveness of this form of fuel when used in a specially designed furnace.

A small high-speed oil-fired tool-hardening furnace by Alldays and Onions, Ltd., is shown on this stand, and attention is directed to a small fan supplying the blast to this furnace. The oil-fired brass billet furnace shown is designed and manufactured by John F. Askam, and is used for heating-up small and medium-sized billets for press work. This furnace, which is shown in Fig. 8, is very economical in operation, the consumption of oil varying between $\frac{3}{4}$ and 1 gal. per hour, according to the weight of metal heated. A new design of laboratory furnace is also shown by J. F. Askam, which is not only suitable for ordinary laboratory work, but also for pottery firing, hardening small tools, and for enamelling purposes.

It will be noticed that Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., have incorporated a new feature in their non-crucible semi-rotary in the form of a tapping valve, the design of which is shown in Fig. 9. This is a draw-off valve, which enables the furnace to be emptied without any variation in the position of the outlet nozzle. This feature is particularly useful when it is possible to pour the metal direct into the moulds instead of by transfer through a ladle. The moulds being brought close up to the nozzle reduces the surface of metal exposed to oxidation, and obviously labour is reduced, since it overcomes the necessity of handling the metal by the shank method. The position of this new feature in relation to the furnace is shown in Fig. 10.

Another melting furnace that invariably attracts attention is that exhibited by British Reverberatory Furnaces, Ltd. This is one of the firm's well-known range of oil-fired economical non-ferrous melting furnaces of 600 lb. capacity. It is especially designed to give rapid melting, the oil-burning equipment combining the latest practice in low-pressure air atomisation, which in conjunction with an efficient air preheating system provides for low running costs—the oil consumption per hour being 7 to $7\frac{1}{2}$ gals., with a melting time of 30 to 35 mins. per charge of 600 lb. The metal is under observation during the entire melting process by a combined inspection door and tapping spout. An interesting feature of this furnace is the removable roof, which allows for easy access to the furnace interior for patching and repairs. A 300-lb. oil-fired aluminium or lead melting pot furnace by Urquhart's (1926), Ltd., will be on view.

The demand for very close limits in the heat-treatment of small parts for all classes of work have caused Burdens, Ltd., to study this important factor, and they exhibit a furnace, Fig. 11, designed for temperatures ranging between 600° and 1,000° C., in which any temperature within this range can be controlled within very fine limits. For this purpose it is fitted with a McLaren type thermostat. This thermostat control is set by a master valve to pass the requisite amount of oil required to maintain a specific temperature. By the introduction of this valve the drawback experienced on thermostat controls has now been entirely eliminated.

Revolutionary equipment suitable for every kind of heat-treatment operation in modern industry is the claim

Fig. 11.—Designed for temperatures between 600° and 1,000° C., this furnace is fitted with a thermostat

of the International Furnace Equipment Co., Ltd., who exhibit the new "International" Omnicontrol recuperative heat-treatment furnace. It is a development of this firm's "Super" heat-treatment plants. The design embodies the radiant wall system of construction, together with automatic control of both temperature and atmosphere. Once these controls are set at predetermined values the furnace will operate without attention and with tool-room accuracy. With this furnace it is claimed that scaleless annealing is accomplished without the use of pots. The latest addition to the wide range of existing Morgans' patent tilting furnaces will be exhibited (Fig. 12). This is an oil-fired tilting furnace, fitted with a crucible of 400 lb. (brass) capacity. A range of ten sizes, from 200 lb. to 1 ton capacity is available in two patterns, central-axis. In these furnaces it is claimed that, as the zone of maximum temperature is disposed around the lower well of the crucible, strong convection currents are set up, and the whole charge is thereby thoroughly well mixed and uniformly heated to the desired pitch.

An interesting furnace will be shown by Manchester Furnaces, Ltd., incorporating many features that meet the need for accurately controlled heat at low cost of maintenance. In addition to furnaces, many designs of burners will be displayed, notably those by Manchester Furnaces, Ltd., the Morgan Crucible Co., Ltd., Laidlaw, Drew and Co., Ltd., the Wallsend Slipway and Engineering Co., Ltd. The latter firm include their latest design of low-air-pressure burner suitable for furnaces for all types of industrial furnaces.

Bright annealing is an important recent development, and the belt-conveyer bright annealing furnace exhibited

Fig. 12.—Recent addition to a range of tilting furnaces.

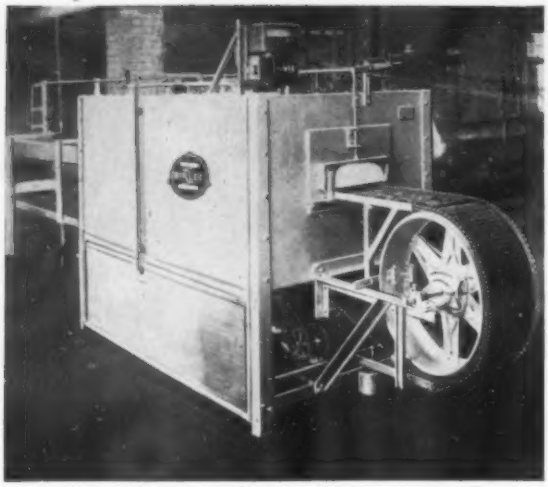


Fig. 13.—Belt conveyer bright annealing furnace.

by Birmingham Electric Furnaces, Ltd., one of four furnaces exhibited by this firm, will have more than ordinary interest. This type of equipment renders unnecessary the elaborate, inconvenient, and costly apparatus previously required for cleaning the oxide from annealed work. The principle of operation consists in maintaining the work in a neutral or reducing atmosphere while it is given the required heat-treatment, and afterwards while it is cooled to a temperature at which it may be exposed to air without the formation of oxide. The furnace, which is shown in Fig. 13, comprises a heating chamber joined to a somewhat longer chamber of metal provided with a water jacket. A strong but light belt of heat-resisting wire mesh passes continuously through both chambers.

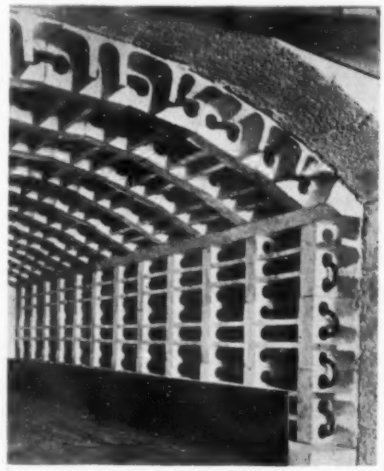
Gas, which may be of a composition suited to the process, and which is supplied, in this case, by an ammonia burner plant manufactured by Messrs. I.C.I., Ltd., is admitted to the heating chamber at the end where the belt enters, and is allowed to fill the heating and cooling chambers, escaping at the exit end of the latter. The temperature of the heating chambers is automatically controlled, and the speed of the belt is adjusted by means of a simple variable-stroke ratchet mechanism, so that the work shall remain in the heating chamber for the time required by the desired treatment. The work emerges from the cooling chamber completely free from oxide, and it has been found that if a suitable reducing gas is used even oxidised work may be made clean by passing it through the furnace.

Fig. 15.—New type of furnace with forced-air circulation.

Another new exhibit by this firm is a forced-air-circulation furnace for low-temperature heat-treatment, which is shown for the first time at the Fair. In addition to these two new models, two furnaces employing the Birlec patent "Curtain-Curtain" method of atmosphere control in its latest and improved form will be seen in operation.

Convincing testimony to the success of the application of electricity to industrial heating requirements is revealed by General Electric Company's exhibits of plant for the bright annealing of metals and for the melting of metal. The former is a 30-kw. furnace fitted with a water-cooling zone at the discharge end. Its design and arrangement are such as to ensure that every part of each individual strip receives precisely the same heat-treatment. The temperature of the strip can be adjusted exactly and maintained automatically. These factors ensure an exceptional uniformity of anneal and facilitate the repetition of previously successful operations. The annealed strip leaves the furnace perfectly bright and free from oxidation. The artificial atmosphere within the furnace is produced by an electrically heated ammonia burner fitted with the usual cleaning and cooling arrangements.

Fig. 14.—Showing support of hairpin elements.



For metal melting a model of a Witton high-frequency furnace (Stobie patent) is shown—a type of furnace which is proving in practice to be not only highly satisfactory, but economical for melting steel, ferrous alloys, and some non-ferrous alloys, such as nickel chromium, etc., producing billets, bars, and castings precisely to specification.

Amongst the electric-furnace exhibits those of Wild-Barfield Electric Furnaces, Ltd., will create not the least interest. Several furnaces will be on view, and only brief reference can be made to them here. One is a box-type furnace for carburising, reheating, hardening, etc., suitable for temperatures up to 1,100° C., and it is interesting to note that a furnace of the same type has been operating entirely satisfactorily for many months at temperatures between 1,200° C. and 1,300° C. The long immunity from breakdowns is due to the heavy "hairpin" elements which are fitted. Fig. 14 shows these elements in position, and it will be observed that they are adequately supported, yet free to radiate into the chamber. The elements are made of pyromic nickel-chromium, and when replacement is necessary each individual hairpin can be removed by the user, whilst the furnace is hot. Full automatic time and temperature control equipment is fitted.

A new type of furnace with forced air circulation (Fig. 15) will be in operation. The patent centrifugal fan is incorporated in the bottom of the chamber. The equipment is complete with a Wild-Barfield-Foster charge progress recorder and automatic temperature control.

Industrial Instruments and Apparatus.

Considerable progress has been made during the past year in temperature control apparatus in connection with fuel and electrically heated plant, and those interested in

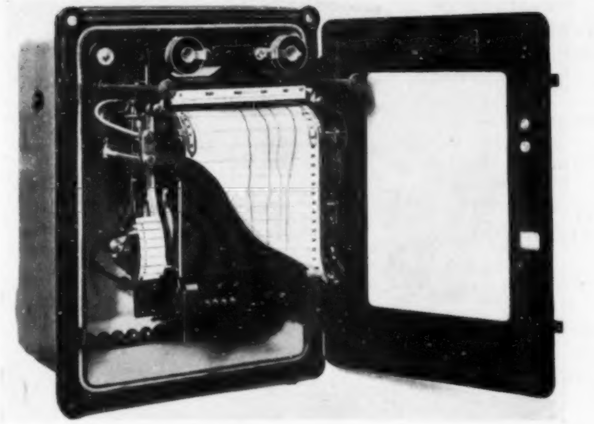


Fig. 16.—Continuous strip chart temperature recorder.

tempering furnaces and heat-treatment plant generally should make a special point of inspecting the various types of instruments now available. Many are shown in conjunction with the furnace exhibits on the Shell Mex and B.P. Stand, and attention is directed to the indicating and recording controllers of the Foster Instrument Co., which regulate the air and oil fuel in the desired ratios.

The synchronous motor-driven, continuous-strip chart temperature recorder by Electroflo Meters Co., Ltd., on the exhibit of Combustions, Ltd., should not be overlooked. An interior view of this recorder is shown in Fig. 16. This is an elaborate multiple recorder, possessing the highest degree of accuracy. It has a sensitivity of the order of 0·43 micro-amperes per millimetre deflection, and an internal resistance of 18 ohms per millivolt (av.).

There has always been a demand for a low-priced continuous electric temperature recorder which is reliable, and the mechanical clock-driven recording pyrograph by Electroflo Meters Co., Ltd., will command attention. This apparatus, which is fitted to an oil-fired furnace by the Incandescent Heat Co., Ltd., records legibly and continuously, although marketed at a low price.

An automatic temperature regulator on the combined stand of the British Commercial Gas Association and the Birmingham Corporation Gas Department, is also exhibited by Electroflo Meters Co., Ltd., an interior illustration of which is shown in Fig. 17. In design this control pyrometer shows a radical departure from previous ideas. It is noticeable that no auxiliary relays are required, no metal-to-metal contacts, and all undesirable complications are eliminated, with the result that the degree of reliability must be very high. This control pyrometer is guaranteed to maintain the desired temperature at the point of temperature measurement within $\pm 0{\cdot}5\%$, and few industrial processes demand closer limits.

A charge progress recorder for use on electric furnaces of the air circulation type is also demonstrated by Wild-Barfield Electric Furnaces, Ltd., and Birmingham Electric Furnaces, Ltd., which in addition to maintaining automatically any desired temperature, shows the operator when the furnace charge has acquired the desired degree of heat. For this purpose a two-point recorder is used which measures the temperature of the hot air before and after it passes through the load. The two records are in different colours to facilitate reading. This apparatus is by the Foster Instrument Co.

A comprehensive range of instruments for industrial use will be exhibited by the Cambridge Instrument Co., Ltd. These will comprise temperature measuring instruments, electrical CO_2 recorders, draught and pressure recorders, smoke density recorder, and other instruments for engineering and electrical measurements, many of which are new. A feature of this exhibit is the arrangement of typical groups of newly designed flush-mounted instruments, mounted on panels as they would be actually installed in a power plant or works. For example, one panel carries six flush-mounted instruments, and comprises an indicating thermometer, a draught gauge, electrical CO_2 indicator, pressure recorder, electrical distance thermometer indicator, and a potentiometric recorder giving continuous records of temperatures measured by thermo-electric pyrometers. A second panel comprises an index thermometer, a draught gauge, a 3-pen pressure recorder, and a 4-unit indicator giving readings of draught, CO_2 percentages, and temperatures measured by both the thermo-electric and the electrical distance methods. A third panel carries three indicators of a new type in which the pointer is fixed and the scale, which is illuminated and considerably enlarged, moves past the pointer. The illuminated moving-scale indicator shown in Fig. 18 will be a special feature of this exhibit.

Welding and Equipment.

The ever-growing use of fabrication in engineering construction has brought welding equipment into prominence, and excellent examples will be on view at Birmingham which will show the progress made to meet demands. Visitors interested in these developments should inspect the exhibits of the English Electric Co., Ltd. the British Oxygen Co., Ltd., G. D. Peters and Co., Ltd., Holden and Hunt, Reyrolles and Murex Welding Processes, Ltd.

Many firms have made a special study of the special requirements necessary for electric arc welding generators. The stability of the arc is necessary if a consistently sound

Fig. 17.—Automatic temperature regulator.

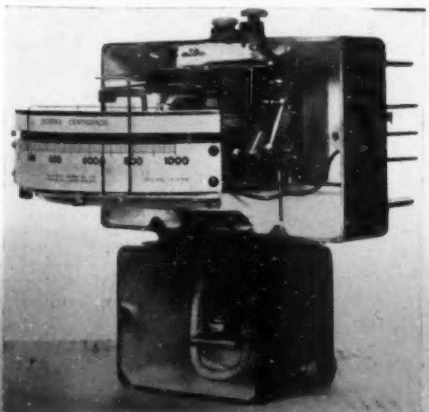
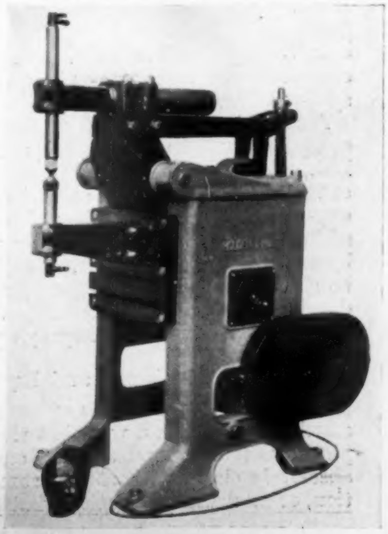


Fig. 18.—Illuminated moving-scale indicator.

Fig. 21.—New spot-welder model.



weld is to be made, but the ease of striking the arc must be considered in addition to its maintenance. In the "English Electric" generator no external resistance is necessary, control being provided by a small regulator in the field circuit. Several generator sets are exhibited by G. D. Peters and Co., Ltd. The special design of these (Fig. 19) enables any desired current, up to the capacity of the machine, to be obtained with automatically correct arc voltage for any electrode.

The exhibit by Messrs. Holmes on Reyrolles' stand, consists of a welding generator which can be coupled to an alternating-current or direct-current driving motor, or to a petrol engine. The control-gear and resistances are fitted above the generator, and so arranged that good ventilation is secured at all times. The set shown in Fig. 20 is a single-operator equipment of 200-ampere capacity, and is suitable for working from a 400-volt 3-phase, 50-cycle supply.

Murex Welding Processes, Ltd., have now placed on the market a three-phase static transformer, portable and self-contained, made to suit any voltage, serving one or two welders, which costs very little more than an ordinary single-operator machine, also having the advantage of very low current consumption. In addition to the latter, they exhibit a machine specially designed for welding thin metal. Several new types of welding electrodes have been developed by this company, which will be demonstrated. Particular interest will be taken in their new electrode, "Fastx," for high-speed steel.

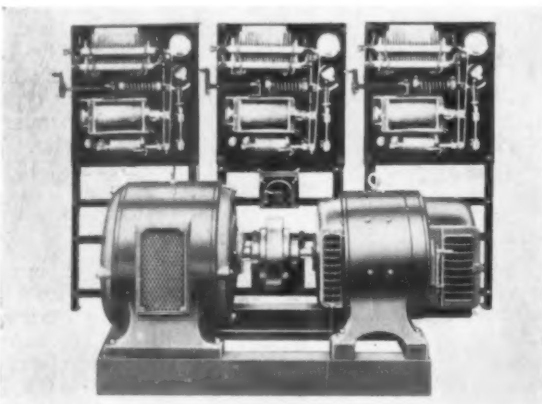


Fig. 19.—Generator which enables any voltage to be obtained up to the capacity of the machine.

A complete range of electric resistance welding machines of the spot and butt types will be exhibited by Holden and Hunt. All the machines shown will be in operation, and particular attention is directed to the new models, a foot-operated spot-welder (Fig. 21), a power-driven, self-contained continuous spot-welder, and the small bench-type spot-welder for dental uses.

Acetylene welding and cutting and electric welding equipment will be exhibited by the British Oxygen Co., Ltd., and many visitors will be interested in the specimens of tests which have been carried out by this company on oxy-acetylene and electric welds and oxygen cuts, in addition to the many practical examples of work executed by each of these processes. Cutting demonstrations will be given on machines designed by this company. A new development which has recently been taken over is the metallisation processes of spraying metals.

Machines and Equipment.

One of the requirements of manufacturers is to handle small parts in such a way that they can be tipped into a plant without separation, and emerge at the other end absolutely clean, without any rumbling, rotation, separation, or mechanical agitation whatsoever. This is precisely

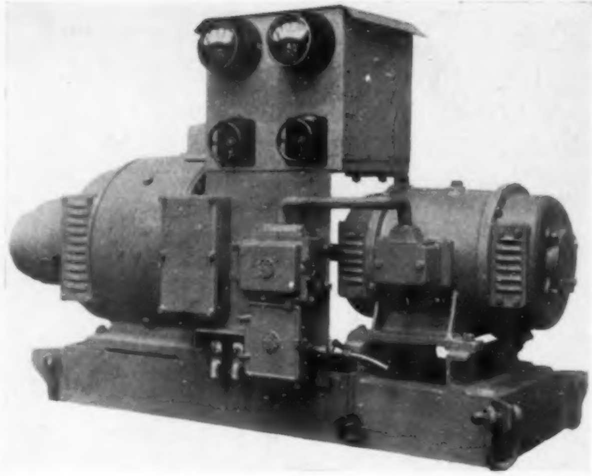


Fig. 20.—Single-operator equipment of 200-amp. capacity.

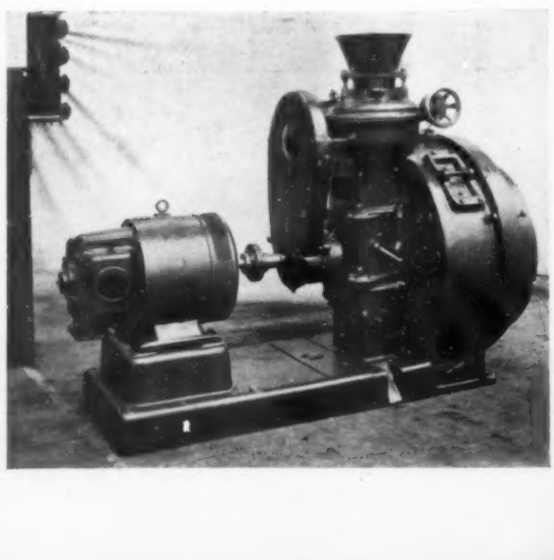
what is being done with the degreasing and cleaning plant exhibited by the Imperial Chemical Industries, Ltd. The cleaning is done by means of trichlorethylene, a non-inflammable solvent. The degreasing exhibit by this company will therefore be an important one, as both stationary and continuous operating plants will be on view, capable of removing dirt, grease, swarf, etc., from practically every type of metal article—hollow, solid, or intricate design,—and of turning them out clean, dry, and ready for plating, lacquering, rust-proofing, etc. In addition to degreasing, water-softening and sterilisation and case-hardening will give the exhibit a popular as well as trade interest.

Alfred Herbert, Ltd., are exhibiting one of their Atritor coal-pulverising machines firing a forge furnace (Fig. 22). This working exhibit demonstrates the advantages of mechanical firing for this purpose. A working model of a Hanrez-Modave patent dust-arresting and desulphurising plant for the purification of flue gases is also shown.

Various forms of presses in operation will attract considerable attention: of these mention may be made of the exhibits of Taylor and Challen, Ltd. A number of presses will also be exhibited by F. J. Edwards, Ltd. Several shearing machines on this stand are of interest, particularly a universal machine with 30-in. throat. Several portable pipe-screwing machines are shown by the "Spiro" Ball Bearing Co., Ltd. These are a new departure, and operate on the principle of milling the thread by a circular cutter.

(Other features have been held over through lack of space.)

Fig. 22.—Atritor coal-pulverising machine firing forge furnace.



ALLOY STEELS—their Development and Application

By J. W. Donaldson, D.Sc.

Recent developments in alloy steels include their wider application for constructional and engineering purposes, the production of heat-resisting steels and alloys, and the super-hardening of steel and its application in general engineering. These developments are discussed in this article.

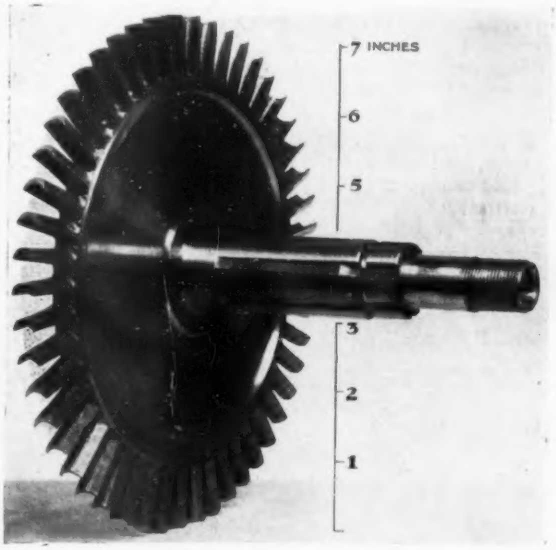
THE introduction and development of alloy steels resulted from an endeavour to improve the limited qualities of ordinary carbon steel, and to provide engineers and other users of steel with materials which were not only strong and hard, but were at the same time tough, ductile, resistant to shock and impact, and possessed good fatigue values. Since the introduction of the earliest alloy steels, as a result of the large amount of research work which has been carried out, considerable progress has been made. The technique employed in the melting, rolling, forging, and heat-treatment of such materials is now of a very high standard, and by suitable selection the mass effect on heat-treatment is largely overcome, and results are obtained from treatment which are very consistent and regular.

The high tensile alloy steels available for engineering and industrial purposes are very numerous, and recent developments have tended to the standardisation of such steels and to their extended use for various constructional purposes, rather than to the development of new alloys. New steels and alloys have been developed, however, and if those manufactured for corrosion-resisting purposes are omitted, it is found that such materials are produced either for heat-resisting purposes or to withstand excessive wear. This has followed from advances in chemical, engineering, and metallurgical technique, which involves many processes where temperatures between 600° and 1,200° C. are attained, and where the durability and life of parts and plants within this range of temperature are of considerable importance. The industrial application of special alloy steels which can be casehardened by means of nitrogen, with the consequent production of a super-hardened surface, has also been an outstanding development in alloy steel metallurgy. Recent developments in alloy steels include, therefore, their wider application for constructional and engineering purposes, the production of heat-resisting steels and alloys, and the super-hardening of steel and its application in general engineering.

Constructional Alloy Steels.

The use of carbon steels for constructional purposes has become more and more limited in many industries. In the aircraft and automobile construction the development of the high-powered aeroplane and the high-efficiency car have demanded transmission of increased power without a corresponding increase in weight, with the result that where steel is used alloy steels have almost entirely displaced carbon steels. Air-hardening steels with a high nickel, high chromium content, or nickel-chromium-molybdenum or nickel-chromium-vanadium steels, are the types principally used for transmission, reciprocating, and gearing parts in such construction, although the more recently developed molydenum-manganese steels, which are less costly, are also finding a distinct application.

In railway engineering, in locomotive construction, there is a growing tendency to use more alloy steels. Nickel steel is used for the boiler of high-pressure, high-speed locomotives, either in the form of plates or in seamless forged drums. A low carbon, 2% nickel steel, with rather high manganese, has been found to be particularly suited for frames, and has good welding qualities. Nickel-chromium and nickel-chromium-molybdenum steels are being increasingly adopted for highly stressed parts, such as connecting-rods and piston rods, and the former steel has also been used for axles and for crankpins. The use of such steels has perhaps been more general in America and certain foreign countries, but they have also been used in this country and their use is rapidly extending.



Exhaust turbine rotor, in "ERA/ATV" steel, used for boosting the supply of air to motors of aeroplanes at high altitudes.

The development of high-pressure boilers with temperatures up to 1,000° F., and pressures up to 1,500 lb. per sq. in., has also necessitated the use of alloy steels, principally nickel steels, containing 3 to 5% nickel, on account of their marked resistance to ageing. The value of nickel in reducing susceptibility to ageing and embrittlement was established by research some years ago, and service experience since then has confirmed the data so obtained, and has led to any increasing use of such steels.

In shipbuilding little use has been made so far of alloy steels, either for decorative or structural purposes, but a tendency in this direction was indicated at a recent meeting of the American Society of Naval Architects and Marine Engineers[1], when the potential values of various types of alloy steels, including nickel, nickel-chromium, silicon, chromium, chromium-manganese-silicon, and chromium-vanadium-silicon were discussed. In marine engineering, there is a growing use for alloy steels, not only for gearing and turbine parts, but also for many parts in heavy oil engines.

Other recent constructional and industrial uses of alloy steels have been the use of austenitic nickel-chromium steels for expansion plates in bridge construction where

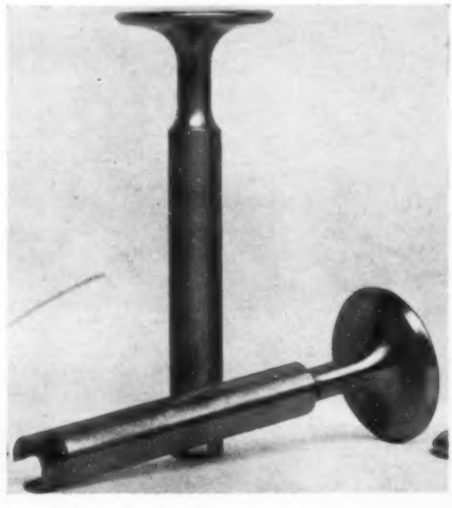
1 W. Bennett, Soc. of Naval Architects and Marine Engineers, 1931, advance copy.

such parts are subjected to heavy wear, and of nickel-chromium-molybdenum steels for gas cylinders which have to remain rigid under particularly severe conditions In mining equipment, nickel steels are also being increasingly used for parts in mine hauling and raising equipment, and for the manufacture of drills, reamers, valves, and chains; and a nickel-molybdenum steel has been found particularly suitable for cutters for oil-well drilling, where there is excessive shock and abrasion.

The machine-tool industry is another branch of engineering which has made considerable use of alloys and alloy steels during recent years, with a considerable increase in cutting speeds and a considerable saving in cutting times. Various nickel and nickel-chromium steels are now in general use for both hot and cold working tools. Improvements in the durability and cutting speeds of the high-speed tool steels have been made by increasing the tungtsen content, while the tungsten carbide alloys, manufactured in Germany and America under the name of Widia and Carbaloy, and in this country as Wimet are not only displacing the carbon tool steels, but also the high-speed tool and the alloy tool steels in the cutting of hard and abrasive materials, and in speeding-up production and output.

Siemens O.H. valves in "380" alloy steel, and ordinary steel, after similar service.

K.E. 965 valve steel.



"ERA/ATV" valve steel

Valves in modern high-speed internal-combustion engines call for a material of the highest characteristics.

Heat-resisting Steels and Alloys.

The trend of engineering development during the last few years has produced temperatures, pressures, and stresses notably different from those hitherto in use, and it is becoming more and more apparent that materials subject to those stresses and temperatures do not possess permanency of structure, properties, or dimensions. In recent years a considerable amount of work has been published on the strength of metals at elevated temperatures, and on the flow or creep that occurs in metals and alloys at such temperatures. The high-temperature properties of steels, and methods for their determination have been the subject of a number of papers during the last year, and a fair amount of data on alloy steels has been published.

An important contribution was a paper on the testing of materials for service in high-temperature steam plant, by Bailey and Roberts[2], which was not only a comprehensive discussion of the whole subject of such testing, but also gave valuable information relating to creep tests and the embrittlement of carbon and alloy steels under service conditions. The tests on embrittlement were carried out on steels containing nickel or chromium, or both nickel and chromium, with or without additions of molybdenum, and indicated that resistance to embrittlement appears to be largely a function of composition, and that steels containing 0·6 to 0·8% molybdenum were less susceptible to embrittlement when tested for prolonged periods at 400° to 450° C. Data on the effect of heat-treatment on the impact strength of the nickel-chromium austenitic steels published by the American Society for Testing Materials[3] indicate that such steels are embrittled by heating within the range 425° to 870° C. A short annealing at 870° C., followed by air cooling, restores the impact strength to an extent depending on the intitial treatment of the steel and the duration of the embrittlement treatment.

Another form of embrittlement produced in nickel-chromium austenitic steels is carbide precipitation, resulting from such steels being stressed in tension in the range 550° to 850° C., and as such precipitation occurs at the grain boundaries, intercrystalline fractures result, with consequent failure of the material. According to Monypenny[4], this liability to fracture is found in steels and alloys over a wide range of composition, and has been noted in alloys falling within the limits 10 to 20% chromium, 8 to 40% nickel, 0·07 to 1·2% silicon, and up to 4·5% tungsten. Various investigations are in progress with a view to controlling or eliminating this precipitation, either by treatment or the addition of other elements such as boron, beryllium, molybdenum, or titanium.

High-temperature tests carried out in the engineering department of the National Physical Laboratory have included not only tensile tests, but also impact, fatigue, and torsion tests. Data obtained from such tests have been published by Tapsell and Clenshaw[5] relating to six heat-treated steels, including a 3% nickel steel, a 3·5% nickel, 0·25% chromium steel, a chromium-vanadium steel, a high-chromium steel, and an austenitic nickel-chromium steel (8/18). Creep tests were determined over the range 300° to 600° C., and impact tests on the nickel steel from 0° to 700° C. An investigation has also been initiated dealing with the effect of small alloy additions on the creep properties of carbon steels in the form of hot-rolled plates, and has indicated so far that the addition of 0·5% molybdenum improves the resistance to creep up to 550°, although this improvement is largely determined by the initial heat-treatment to which the steels are subjected. Somewhat similar results have been obtained by Pomp and

2 R. W. Bailey, and A. M. Roberts, *Proc. Inst. of Mech. Eng.*, 1932, vol. 122, p. 209.

3 *American Soc. for Testing Materials*, reprint, June, 1932.

4 J. H. G. Moneypenny, *Iron and Steel Ind.*, 1932, vol. 6, p 9.

5 H. J. Tapsell and W. J. Clenshaw, *Dept. of Scientific and Industrial Research, Special Report*, No. 18, 1932.

Höger[6], by adding small additions of chromium, molybdenum, nickel, and copper to low carbon steels. These were tested in the form of normalised rods, and beneficial results were obtained in the creep tests, particularly with 0·3% molybdenum, especially in the presence of chromium.

The influence of aluminium and silicon additions on the high-temperature mechanical properties, and on the resistance of oxidation and scaling of the high-chromium (16 to 19% chromium) and the 18/8 chromium-nickel steels has been investigated by Oertel and Scheperts[7], and has indicated that the best properties are obtained with 18% chromium, 8% nickel, 0·5 to 1·0 aluminium, and 2 to 2·5 silicon. During the present year researches have also been in progress on the endurance properties of the austenitic nickel-chromium steels under the direction the American Society for Testing Materials[8], but, so far, no results have been published.

The properties required in valve steels and the various types of steel available to meet those requirements were considered in a paper by Handforth[9]. Seven valve steels, including austenitic nickel-chromium steels, silchrome, and cobalt-chromium, were subjected to 1,000 hours' treatment at 750° to 900° C., and all showed some degree of mechanical and structural deterioration. Cracking in valve seats was also considered, and a method of protection by welding Stellite dealt with, although such a method of protection gives rise to many problems particularly with the cobalt-chromium and austenitic steels.

The industrial application of the heat-resisting steels has been continued during the last year in the manufacture of steels and alloys containing from 15 to 25% of chromium, 10 to 30% of nickel, and 2 to 4% of tungsten. These steels are sold under such names as "Era/A.T.V.," "H.R. Crown Max," "K.E. 965," etc., and find various and increasing application for such parts as valves, superheater parts, etc. The valuable increase in creep strength, resulting from the use of small alloy additions to low-carbon steel indicates an advance which may become of considerable industrial importance in the production and substitution of cheaper steels for the more complex alloy steels in many branches of engineering construction, such as boiler construction where the complex steels are prohibited by their cost. The use also of alloy steels free from embrittlement at elevated temperatures due to the addition of molybdenum, should also prove of considerable advantage for the manufacture of bolts, studs, and nuts in high-temperature equipment.

Nitriding Steels.

Since the nitrogen casehardening process was developed in 1920, many scientific data have been complied on the subject, and research work continues to be carried out with a view to improving the process and explaining the phenomena which occur. In a paper to the Iron and Steel Institute in May, 1932, Fry[10] reiterated the view which he had previously expressed, that nitrogen-hardening is not due to the presence of alloy nitrides themselves, but to their influence on the space lattice of iron, where they are precipitated in a highly dispersed form and subject the metal to slip interference, with consequent distortion of the crystal lattice, which produces great hardness. He also gave the analyses of several types of nitriding steels together with their tensile properties after suitable heat-treatment. The most suitable steels are those alloyed with chromium and aluminium, while the presence of 0·25% of molybdenum gives a marked improvement in the heat-treating of large sections, in the machinability, and in the toughness of the nitrided case. Reference was also made to recently developed precipitation-hardening nitriding steels which provide a comparatively soft steel that is easily machined prior to nitriding, and yet is capable of producing a hard core. The composition of one of these steels was given as 0·1% carbon, 2·55% silicon, 1·4% manganese, 2·2% nickel, 0·5% aluminium, and 3·9% titanium.

In the Carnegie Research Memoirs of the Iron and Steel Institute for last year, which have just been published, there is the first part of an investigation into the nitrogen-hardening of steels by Jones and Morgan[11]. The nitriding properties of nitralloy steels are dealt with, with special reference to the effect of constituent elements, and by depth-hardness and depth-nitrogen curves it is shown that aluminium is the element which gives great concentration of both hardness and nitrogen in a narrow zone near the margin, while the addition of chromium and molybdenum to an aluminium steel is essential to obtain a greater hardness at the surface and to a greater depth. Experiments show that this is due to grain refinement. From the results obtained, the mechanism of nitriding is considered, and hardness is attributed to the presence of finely dispersed particles of a complex nitride which consists principally of iron nitride containing aluminium and chromium nitrides, critical amounts of which cause sufficient distortion of the crystal lattice of iron to effect an extraordinary hardening.

The application of the nitralloy steels, containing 1·0 to 1·5% aluminium, 1·3 to 1·8% chromium, and 0·2 to 0·3% molybdenum, which, on hardening, have a hardness value of over 1,000 Brinell to the depth of 0·025 in., for various parts which have to withstand excessive wear in the engineering and other industries, have had a wide development during recent years, and the last year has seen a marked extension of their uses. For valve parts subjected to excessive abrasions and erosion, nitrided steels have been used with considerable advantage. They have also been used extensively for the manufacture of cams and gears, for which they are particularly suitable, and in the production of internal-combustion engine crankshafts, pump plungers, and gudgeon pins.

Progress in Rust- and Acid-Resisting Steels

(*Continued from page* 110).

welding, when heating to the softening temperature, followed by quick cooling, is recommended. This treatment is especially desirable after welding, not only because of the effect of the temperatures induced by welding, as regards corrosion resistance, but particularly to remove the residual stresses left by the welding operation. If the shape, size, or other considerations make this impracticable, then the special austenitic steels containing small additions of tungsten and titanium should be employed. The presence of these special elements prevents the heat effects resulting in those structural changes in the material which, in the presence of certain critical corroding media, may lead to intercrystalline corrosion.

It can be stated without fear of contradiction that although wrought iron has been used since the end of the Stone Age, and mild steel since the advent of the Bessemer process, there is still much we do not know about those useful metals. The austenitic steels, therefore, arriving late, as they have done, still require, and will doubtless receive, the greatest attention of metallurgical investigators, and intimate collaboration between the producer and user will do much to eliminate any outstanding difficulties. The extension of established applications is facilitated by experience already gained, but where new applications are under consideration the producer should be fully consulted. These special steels are not employed unless difficulties of corrosion have to be surmounted ; why should not the whole of the conditions, as known, be placed upon the table in such cases for the consideration of the steel-maker and his metallurgical advisers, and if the conditions, as frequently happens, are not quantitatively known, then let them be determined by collaboration ?

Certain recent applications are illustrated, and these will no doubt suggest others to the mind of the reader.

6 A. Pomp and W. Höger, *Metallurgist*, 1932, vol. 8, p. 87.
7 W. Oertel and A. Scheperts, *Stahl u. Eisen*, 1932, p. 511.
8 *American Soc. for Testing Materials, Bulletin*, April, 1932, p. 13.
9 J. R. Handforth, *Iron and Steel Inst.* Sept., 1932.
10 A. Fry, *J. Iron and Steel Inst.*, 1932, vol. 125, p. 191.
11 B. Jones and H. E. Morgan, *J. Iron and Steel Inst.*, Carnegie Scholarship Memoirs, 1932, vol. 21, p. 39.

Correspondence

Surface-Hardening Scientifically.

January 24, 1933.

The Editor, METALLURGIA.

Sir,—I have read with interest Mr. Fletcher's letter, published in the January issue of METALLURGIA, and I regret that, in my article under the above title, published in your November issue, the comparison drawn between the hand operation of surface-hardening and the "Shorter" process is considered to be unfair.

It is agreed that metal surfaces can be hardened by hand manipulation of an oxy-acetylene blowpipe by a thoroughly skilled operator, and I do not question that some excellent results have been obtained over a period of years from work executed by one well practised and versed in the exacting conditions required to produce such results.

I am not in agreement with Mr. Fletcher when he suggests that the process of surface-hardening is essentially the same whether the flame is operated by hand or traversed by mechanical means, as provided in the "Shorter" process. There is a fundamental difference, not only in the operation itself, but also in the results produced.

In referring to the marking of the etched surfaces, it was not suggested that these indicated internal stresses. They do, however, coincide with surface stresses, or the hard and soft areas, so irregularly distributed over the surface area. The surface metal is in a state of pearlitic, sorbitic, or martensitic condition, due to certain portions not having been hardened, others having been partially hardened, and some fully hardened.

The oscillating action of the heating medium over the surface, together with a fluctuating and irregular quench, unquestionably results in a lack of uniformity of hardness, and an irregularly stressed condition which is most detrimental.* This results from rehardening, or partial rehardening, of an already fully stressed material, or, what is worse, an overlapping of treatment that is highly detrimental and likely to lead to cracking, fissures, and flaking of the tooth flank.

In the process referred to in the article oscillation is definitely and rigorously prevented, and the above condition is eliminated by reason of a continuously progressive treatment wherein heating and quenching are definitely in one direction and progressive, and the heating and quenching media are in a constant relative position to the surface and throughout the whole length of the object under treatment. It will thus be seen that alternating, irregular, or interposed stresses are obviated and the hardened steel is in a uniformly martensitic condition for a definite depth, below which is a gradual gradation of structure through the sorbitic towards the normal or pearlitic structure of the core. If irregularities have been formed they have been in depth of treatment only and cannot be detrimental, and would not be due to overlapping or alternating hard and soft places.

Mr. Fletcher is particular to state that equally good results can be obtained with the hand control if *ideal conditions be secured*. Doubtless it is possible, after long experience, to control to some extent conditions which produce satisfactory results. But such is not general. The human hand is not steady enough to maintain constant results, especially after some hours' work, and the illustrations which were given in the writer's article are by no means exaggerated or uncommon, as many cases have been brought to his attention to the prejudice of the improved mechanical system. I have seen several cases of considerable wastage resulting from the hand method in the hands of inexperienced persons who, with very little training, could safely have operated the "Shorter" process with definite success.

It should also be pointed out that Mr. Fletcher's reference is largely to one particular class of gear of a tooth size which lends itself to hand treatment in the hands of a skilled operator, but innumerable attempts have been made to apply the hand system to both smaller and larger gear teeth of sizes which make it impossible to produce results that could be termed at all satisfactory.

The process I stressed is being applied with absolute success to gears of 10 diametrical pitch, and as large as 5-in. circular pitch, also to worms and the journals of shafts of various sizes. From this it will be seen that the mechanical control has brought a vast range of work within possibility of achievement which, by the hand method, would be impossible in practice.

There is nothing misleading in my article in regard to the shape of the hardened zone, and anyone is welcome to submit a wheel to us for treatment and to section it throughout at their pleasure for comparison with the illustrations shown. It is not fair to etch the end of a hardened gear to ascertain the shape of the hardened zone, for the reason that the extreme ends are not reasonable examples of the work.

I am glad that Mr. Fletcher recognises the ideal in the straight-line motion of the hardening flame along the length of the tooth; surely this is a contradiction of his suggestion that the oscillating flame has its advantages.

The great success which has resulted from a wide application of the "Shorter" process during a number of years has converted many important engineers, who were disappointed with the results of the hand system, into appreciative users of the mechanically controlled system. —Yours, etc.,

A. E. SHORTER,
Managing Director.
The Patent Gear and Metal Hardening Co., Ltd.
Westminster, S.W. 1.

February 4, 1933.

The Editor, METALLURGIA.

Sir,—We have read Mr. Shorter's letter of the 24th, and regret that he has misread or misconstrued the points raised in my letter of January 6, and has dealt with the misconstruction rather than the points actually made in the letter. For instance, referring to mechanical hardening, I did not say in my letter that "equally good results can be obtained with the hand control if ideal conditions be secured." What I actually said, after claiming that both processes were fundamentally the same in principle, was that "if ideal conditions could be secured equally good results would be obtained by either mechanical or hand control."

The only important differences claimed for mechanical surface-hardening, compared with hand operation, are in the maintenance of more uniform hardening conditions, and in the straight-line motion of the flame. A straight-line motion could, of course, be used with hand operation if this were felt to be the best practice. I maintain, therefore, that there is no foundation for Mr. Shorter's assertion that "There is a *fundamental* difference not only in the operation itself but also in the results produced," and I would point out that no evidence has been put forward by Mr. Shorter in support of his view.

It is also incorrect for Mr. Shorter to say that "Mr. Fletcher recognises the ideal in the straight-line motion of the hardening flame along the length of the tooth." What I did say was that whilst the straight-line motion of the flame was the most convenient for mechanical operation, there are actually cogent reasons in favour of the oscillating flame.

Mr. Shorter still seems to be under a misapprehension regarding the effect of flame oscillation on internal stress. Fig. 1 in his article in the November issue of METALLURGIA showed a photograph of a gear tooth that had been etched to show the Martensite-Troostite banding produced by an oscillating flame, the caption being "hand-treatment stresses." Again, in his letter of January 24, he states that such markings "coincide with surface stresses, or the hard and soft areas so irregularly distributed over the surface

* See paper on "Metal Surface Hardening," by A. E. Shorter, read before Institution of Welding Engineers.

area." Unquestionably such variations in structure will incur some irregularity in internal stress, but the important points to realise are :—

(i.) That the irregularity in hardness with reasonably good operation is nothing like as pronounced as the etching characteristics suggest ; and

(ii.) that the maximum stress in the hardened teeth is not necessarily greatest in those showing the greatest etching contrasts.

With regard to (i.) above, hardness tests we have recently made over the whole length of a number of teeth (*a*) hardened by the oscillating-flame method, according to our normal practice, and (*b*) hardened by the Shorter machine, showed the same order of hardness notwithstanding the fact that the former teeth showed well-marked banding, whilst the latter appeared uniform after etching. All the teeth were, of course, of the same steel, the same gear, in fact, and actually the hardest teeth of those tested had been hardened by hand.

With regard to (ii.) above, the maximum stress left in the teeth after hardening is of extreme importance in relation to the life of gears, and it is quite wrong to suppose that teeth uniformly hardened will necessarily show a better performance than teeth hardened with the oscillating flame. To illustrate this point we show in the photograph, Fig. 1, herewith, the effect of undue hardening stresses on a tooth

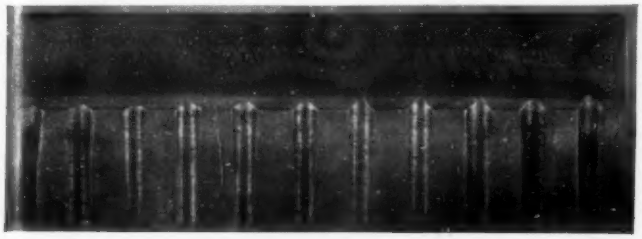


Fig. 1.—Effect of undue hardening stresses.

that showed a straight and uniform etching hardened zone, and which had, in fact, been treated mechanically by Mr. Shorter's own machine and operator. As can be seen in the photograph the hardened layer contains a continuous network of cracks, many of which were shown by micro-examination to penetrate practically the full depth of the hard layer. The effect is similar to that sometimes produced by too-rapid grinding after hardening, although, in this case, no grinding or other treatment had been applied after hardening. It should be explained that the cracks were too fine to be visible on superficial examination, but were immediately shown up by a magnetic method, as seen in Fig. 1.

The above example of hardening cracks, produced by surface hardening, is the worst that has come to our notice, and we instance it in support of our view that the mechanical surface-hardening of gears or other parts has not yet been developed to the peak of perfection that Mr. Shorter would have us believe. It is true that a machine may operate uniformly as to speed and other conditions, but as example given above shows the result may also be uniformly bad.

It may interest Mr. Shorter to know that many years ago we also believed that the machine-operated flame would give more consistent and satisfactory results than the hand-operated flame, and we actually designed and built such a machine. Rresults obtained then, however, decided us in favour of the hand-operated flame, and subsequent experience of machine hardening has not caused us to alter that view.

We can assure Mr. Shorter, after many years' experience, that hand operation, given suitable surface-hardening equipment and a reasonably skilled operator, is not nearly as difficult as he evidently believes, and is capable of turning out a first-class job at least equal to that produced by a machine-hardening process and at a lower cost. -Yours, etc.,

(Signed) G. H. FLETCHER,
Chief Engineer and Manager.

Metropolitan-Vickers Electrical Co., Ltd.,
Attercliffe Common Works, Sheffield.

Heat-Treatment of Steel Wire.

January 26, 1933.

The Editor, METALLURGIA.

Sir,—I have read with considerable interest the article on "Heat-treatment of Steel Wire," by a Special Correspondent, in the January issue of your journal. My reason for writing you, however, is that your correspondent makes reference on page 70, in the paragraph headed "Patenting," to the statement that this process was introduced by Wm. Smith, of Warrington. Unfortunately, this statement, which I believe to be incorrect, appeared in my book on "Wire Drawing." Some time after the publication of my book I received a letter from Mr. J. F. Luckman (of Messrs. Latch and Batchelor, Ltd., Birmingham) in which he put before me evidence that I had been seriously misinformed in attributing the origin of the patenting process to Wm. Smith, of Warrington.

My authority for this statement was Bedson. Mr. Luckman, in his letter, from which I quote, states :—

> "That the process was invented by James Horsfall, of Birmingham, who was granted Royal Letters Patent for his invention in 1854. It was due to this that the term 'Patenting' became associated with the process, and the wire produced by that method was known as 'Patent Steel.'
>
> "James Horsfall entered partnership with Baron Webster of Penns, and the two carried on business at Penns and Hay Mills, under the name of 'Webster and Horsfall.'
>
> "The firm supplied wire to John Fowler, of Leeds, and, to meet the requirements of steam ploughing, introduced a hard grade of patent steel, which was known as 'Patent Plough,' afterwards, as tensiles increased, 'Improved Plough' and 'Extra Plough' followed.
>
> "All these world-wide descriptions for wire originated at Hay Mills, as did 'Patent Music' and 'Patent Piano Wire,' and it was here that the whole of the steel wire was made for the first successful Atlantic cable.
>
> "The William Smith referred to in your book was originally in the employ of Webster and Horsfall, but left their service, and, after being for a time associated with Abel Rollason, commenced drawing wire in two cottages at Warrington. The business grew, and after securing the services of another employee of Webster and Horsfall as foreman, commenced heat-treating wire in a way that James Horsfall considered was an infringement of his patent.
>
> "A lawsuit followed, but the verdict went against Horsfall, for, although the object aimed at was the same, the operation was entirely different.
>
> "The process employed by Smith was to wind the wire on to a block in an oven, bring it to the required temperature, then wind it back into the air.
>
> "Horsfall's patent was for the present type of muffle, with metal bath."

Since it was too late to correct this mistake in my book at the time, I take this opportunity of asking you to be good enough to publish it in your journal.

Yours, etc.,
C. E. ADAM.

Levenhall,
Musselburgh.

[We have also received a letter on the subject from Mr. J. F. Luckman to the same effect. Our Special Correspondent discusses "patenting" very fully in a letter which is published on the next page.—EDITOR.]

Origin of "Patenting."

February 4, 1933.

The Editor, Metallurgia.

Sir,—We have read with great interest the letter you have received from Mr. Adam in regard to the claim of the late Mr. Wm. Smith, of Warrington, to be the originator of the generic term "patenting," mentioned in our recent contribution on the "Heat-treatment of Steel Wire." In spite of the letter from Mr. Luckman, which he quotes *in extenso*, we still think there may be some truth in the original statement as contained in page 79 of Mr. Adam's book, and gleaned from the very interesting paper by the late Mr. Jos. Philips Bedson to the Iron and Steel Institute in 1893. Only the latter part of the statement is given by Adam from Vol. XLIV., *Proc. I. and S. Inst.*, page 92, where Mr. Bedson strikes at the root of the difference between the rival claims when he says :—"I believe it is to Mr. Horsfall, of Birmingham, in 1854, that the credit of the first attempt to *harden and temper* cast-steel wire is due, but it is to the late Mr. Wm. Smith, of Warrington, that the secret of the 'Patenting' wire process of to-day is due." The difference is also pointed out by Mr. Luckman's statement that Smith used a process which we can identify to-day as "beehive oven" patenting, which definitely produces an overheated structure, whereas Horsfall used the muffle furnace and metal bath which generally produce a refined or small-grain size, unless very high temperatures are employed. It is not stated if the muffle-furnace method of heat-treatment was continuous, although this is highly probable as affording another contrast to the "beehive" method, which was intermittent, and it is interesting historically to note that Mr. George Bedson, who invented continuous rod rolling in 1862 had already patented continuous galvanising two years before, and in 1870 extended his "tubing" furnace to enable continuous "patenting" to be developed on the same lines, but at higher temperatures.

As tending to show how a general statement may be misinterpreted we might very well challenge the claim put forward by Mr. Luckman for Messrs. Webster and Horsfall's mills that : "It was here that the whole of the *steel* wire was made for the *first* successful Atlantic cable." Against this claim, which bears no date, we may advance the fact that Mr. Bedson mentions on page 83 of his paper on "Iron and Steel Wire and the Development of its Manufacture," referred to above, that his father took charge of a wire mill in Manchester,* and here undertook the drawing of the *iron* wire for the Dover-Calais submarine cable, "as well as the production of half the wire for the *first* Atlantic cable." "As 22 g. wire was required for this, the drawing of this wire not only taxed the Manchester firm to its utmost, but several of the Yorkshire wire-drawers had to finish large quantities (from 11 g.) which was under Mr. Bedson's supervision. The quantity of wire needed for this order was 950 tons, and it took 1,100 tons of Bradley's charcoal-iron wire rods, No. 4 g. to produce this quantity of finished material." This work was done in 1856, and the cable laid up by April, 1857, only to be broken in August when the H.M.S. *Agamemnon* got about 380 miles west of Valencia with it. Soon after the cable was laid by starting in mid-ocean, and the two cable-layers, steaming in opposite directions, succeeded in bringing the cable ashore at each side. This first bridging of the Atlantic by submarine cable was successful, and over 730 messages were transmitted before it broke down in 1858, so that Mr. Luckman must mean the next attempt in 1865, when he refers to *steel* wire being used, since the first cable was definitely of wrought iron, as recorded above. We take it as significant that no technical details of our communication have been queried, although the Troostite theory of the Mount Hope bridge wire failure seems to have been doubted by Mr. Adam in his communication to the *Metal Progress*, of January, 1933.—Yours, etc.,

Manchester. Your Special Correspondent.

* Richard Johnson and Nephew Ltd., then in Ancoats.

Surface-Hardening Scientifically.

(*Continued from page* 131.)

February 13, 1933.

The Editor, Metallurgia.

Dear Sir,—Mr. Fletcher, in his defence of the hand method against the machine method of hardening, concluded by an inference that the machine hardening is good, and that it is not beyond the bounds of possibility to produce results equally good by the hand method, but it needs no stretch of imagination to realise that hand methods, even in hardening, must give place to the machine if consistency is required. In my article I gave distinct illustrations of not uncommon irregular work and failures caused by unequally stressed hand hardening. Mr. Fletcher has not proved his contention that the flame oscillation has advantages, and he ignores the seriousness of overlapping stresses ; years of experience and constant laboratory tests of treated specimens leave no room whatever for doubt or misapprehension on this point.

I am sorry Mr. Fletcher has chosen to defend his contentions by taking an example of a "Shorter" hardened gear, which I have not had the privilege to investigate, but it is evident to me from the illustrations he gives of spider-web cracks, that these have been caused by acid etching in the laboratory, and not in actual hardening.

It can be demonstrated that a surface brought to a martensitic condition may be entirely free from cracks, but by acid treatment will develop a network of cracks. (See A.S.T.M. Standard Methods E 3-24).

I contend that the machine method of the "Shorter" process is scientific, and has proved to be so in service.—Yours faithfully,

A. E. Shorter,
Managing Director.
The Patent Gear and Metal Hardening Co., Ltd.,
Westminster, S.W. 1.

Soviet Russia Honours British Scientist.

Sir Robert Hadfield has been unanimously elected an honorary member of the Russian Academy of Sciences, which was formerly the equivalent of Britain's Royal Society. The honour has been conferred upon him in recognition of his distinguished services to metallurgical research. It is of interest to note that Michael Faraday was also a member of the Academy, then styled the Imperial Academy of Sciences, while Dr. P. Kapitza, who has done such splendid scientific work at Cambridge, is also an honorary member of the Russian Academy.

Sir Robert has maintained close terms of friendship with many Russian scientists, and particularly did he hold in high regard the late Professor D. Ischernoff. This honour is not only a personal one, but an honour to British science that is very gratifying.

Stellite-tipped Tools at B.I.F.

Stellite-tipped tools, with a demonstration of the tipping process, solid Stellite tool bits and milling cutter blades, will illustrate the applications of Stellite as a cutting alloy. There will be included also Stellite-tipped lathe centres, Stellite reamers, tube and wire-drawing dies, Stellite-tipped work rests for centreless grinders, and Stellite components used in dry battery manufacture. It is important to note that the last mentioned is an application in which considerable development has taken place during the past year.

In addition to the foregoing, Deloro Smelting and Refining Co., Ltd., are showing numerous applications of the Stelliting process, including Stellited conveyer screws, skidder bars for conveyers, coal picks, etc. The actual process by means of oxy-acetylene torch is being demonstrated on the stand. Particular attention is directed to a drill-chuck which is bushed with Stellite.

Fifteen Years of Soviet Industry

By A Special Correspondent

Rich in natural resources, Russia has made a rapid change by industrialising her vast territory, formerly largely devoted to agriculture. The author describes the success that has been attained, and when the stupendous difficulties with which the U.S.S.R. was confronted are appreciated the results achieved are remarkable.

NOVEMBER 7, 1932, marked the completion of 15 years of Soviet power. In other words, 15 years of development in a country which was doubly handicapped by a mediæval pre-war economy, and by a disastrous war which almost completely ruined the very immature existing industries. The achievements from 1917 to 1932 are all the greater considering that the first years were years of civil war, of famine and pestilence, which reduced the national economy of the country to a still lower level and made the subsequent upward climb much more difficult.

Considering the various stages of industrialisation and reconstruction, we must constantly bear in mind the unique structure of Soviet economy, whose main purpose is the building up of all industry for internal consumption. Thus the predominance of heavy industry as the foundation of both light industry and agriculture in the first Five Year Plan, and, after the achievement of this goal, the greater emphasis laid on light or consumers' industries in the second plan.

Soviet Russia has now entered upon her third economic period, the two first being that of restoration (1917-1927) and that of reconstruction and Five Years Plan (1928-1932).

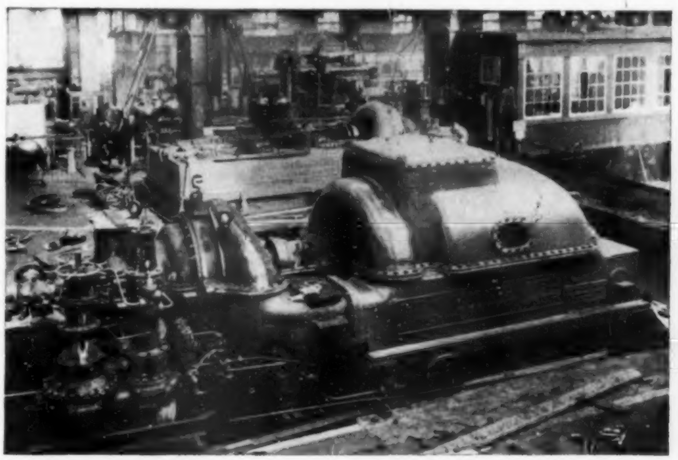
The first years of the reconstruction period, 1917 to 1921, were one long sequel of civil war, fights against foreign intervention, and served only for the consolidation of the Soviets. Obviously it was industry which suffered most during these years. This is appreciated when reference is made to production. For instance, the total value of industrial production fell from 8,430 million roubles in 1913 to 2,540 million roubles in 1921—*i.e.*, one fifth. The output of coal amounted to 8·9 million tons, as against 29 million tons, and pig-iron production had fallen from 4,200,000 tons to 116,300 tons, or 2·8%. Other industries were just as badly hit. On the other hand, however, this low level was confronted with the consolidation of political power, and, therefore, with the will for restoration and reconstruction. Restoration took place in a shorter time than had been expected. It was finished by the end of 1927, as shown by the following figures. Reckoned in pre-war roubles, industrial production in 1926-27 amounted to 8,760 million roubles, or 103·9% of 1913. The coal output had risen from 28·9 million tons in 1913 to 32·3 million tons in 1927; oil from 9·3 to 10·95 million tons, etc.

This development was not a mechanical and automatic process. It was due to the basic changes produced by complete reorganisation of industry, in which, at that time, modernisation was kept in mind; electrification, for instance, played a particularly important rôle, as the first "Goelro" plan, dating back to 1920, showed. In 1927 power production amounted to 4·17 milliard k.w., as against 1·95 milliard k.w. in 1913. In 1926-27 industrial socialisation had advanced so far that 91·3% of the industrial value was owned by the State, 6·4% by the Co-operative Societies, and only 2·3% privately. Thus we find that whilst before the war 42·1% of the gross production was industrial, in 1927-28 it had risen to 45%.

On October 1, 1928, the first Five Year Plan came into operation, and was due to be completed in 1933 (in fact, the Plan was reduced by one year; but since also the year was adjusted to fit the calendar year the Plan came to an end on December 31, 1932). The Plan was intended to transform Russia from primarily an agricultural country to a predominantly industrial one through the establishment of suitable works and factories, and an immense increase in power supply by an extensive electrification scheme.

Electrical Construction.

The amount of electrical energy generated in 1913 in Tsarist Russia was equal to 2,000 million k.w.-hours per annum; in 1928, at the beginning of the Five Year Plan, this figure had increased to 5,000 million k.w.-hours, and at the end of the Plan in 1932 had reached 13,500 million k.w.-hours. In addition to this, it is interesting to note that among the electrical stations of Tsarist Russia there were none with a generating capacity as high as 25,000 k.w.; in 1932, however, under the new régime, 10 large electrical stations are in operation, each with a capacity of more than 100,000 k.w. These stations include the following:—



Turbine construction at the Stalingrad plant.

	K.w.-hours.
Kashira	186,000
Shatura	136,000
Mogess	107,000
Krasny Oktiabr	111,000
Shterovka	157,000
Zuevka	150,000
Dneprogess	310,000
Nijgress	158,000
Cheliabinskaya	110,000
Boginskaya	109,000

Coal.

In the coal industry during the Five Year Plan the foundation has been laid for the development of mechanisation. Since 1928 150 new shafts have been sunk, and these mines, with a total capacity of 63 million tons per annum, are now being worked. A further 150 shafts have been sunk in addition to these, and the mines are in a state of preparation. When finished their capacity is estimated to be 123 million tons per annum.

Some idea of the degree of mechanisation which has been achieved can be realised from the following figures, which show Soviet Union in relation to other industrial countries :—

Amount of Total Coal Cut by Machines.

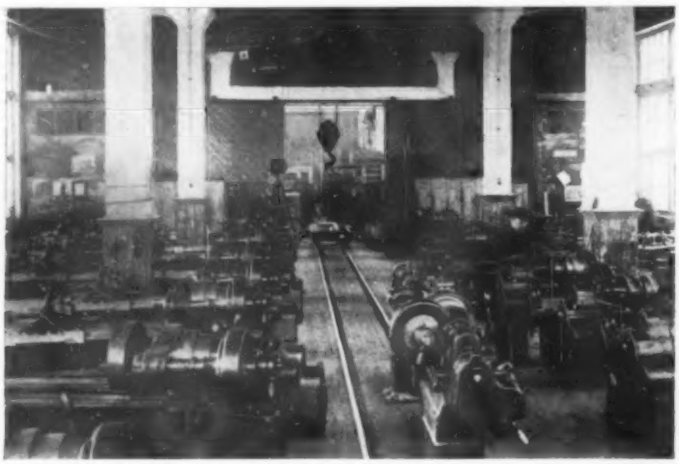
	%
Soviet Russia	72
America	77
France	71
Germany	93
Great Britain	31

During the Five Year Plan the number of coal-cutting machines in the Donbass increased by 240%.

In Russia the average capacity of the mines has increased by 60% during the operation of the Plan.

Metallurgical Progress.

During the last five years many new works have been constructed, and new equipment has been put into operation. The Voikov Works, at Kerchi, and the plants of Magnitogorsk and Kuznetsk are outstanding examples in the iron and steel industry, while in non-ferrous metals there are the Krasni-Ural Copper Combine, the Belov and Constantinov zinc plants, the Voikov Aluminium Combine, and eight concentrating factories. Another series of plants has been radically reconstructed and new high-capacity equipment installed, including blast-furnaces, open-hearth furnaces, and rolling-mill equipment. In others all the equipment has been rebuilt along modern lines, with a view to improved product and increased capacity. Practically all the plants in the South and a number in the Urals have been thus altered, including the Dzerzhinsky, Tomsky, Petrovsky, Lenin, Voroshilov, Stalin works in the Don Basin, Electrostal and Krasni-Octiabre, in Stalingrad, etc.



Machine-tool construction now proceding on modern lines.

Altogether the increase in the production capacity during the first Five Year Plan in the iron and steel industry is as follows : a total of 40 blast-furnaces, including those which were reconstructed and 17 new ones ; 66 open-hearth furnaces, of which 45 are new. For rolling purposes 23 mills have been added, including 11 new ones. As a result, the nature and scope of the iron and steel works have been radically changed. In 1913 the average annual production of pig iron for a single plant was 60,000 tons ; in 1932 the average annual production for one plant was 145,000 tons, and increase of two-and-a-half times. Moreover, at the commencement of the Five Year Plan there was only one blast-furnace with a greater volume than 700 cms., whereas at the end of 1932 there were 10 blast furnaces with a greater volume than that, two with a volume of 1,180 cms. each. Previously there was little mechanisation for charging and pouring metal. By the end of the Five Year Plan there were 10 casting machines, while 11 furnaces are fully mechanised for charging. The first 150-ton, open-hearth furnace of Kuznetsk has been built, and the first modern blooming mill has been put into operation. The first rail-rolling mill, at Kuznetsk, is of the most modern type.

New technique has been applied to production, and considerable progress made in electro-metallurgy. In this connection mention must be made of Electrostal, which from a small experimental plant has grown into a huge steel works with few equals in the world. The output of electric steel constituted 2·1% of the total steel production of the country. New types of high-grade steel are being manufactured in the Union for the first time, such as high-speed steel, rustless steel, non-magnetic steel, steel for ball bearings, molybdenum steel, chromo-nickel steel, etc. The output of high-grade steel has been increased sevenfold during the last five years.

For the production of ferro-alloys a plant has been built at Cheliabinsk, and similar plants will be started in the Dniepre Combine and in Transcaucasia. But what is very important for iron and steel production is the creation of a machine-building base for this industry. Many different kinds of equipment used in iron and steel production are now being manufactured in the Soviet Union, such as blooming mills, powerful rolling equipment, metal casting machines, turbo-compressors, equipment for coke ovens, electric furnaces, including arc and high-frequency electric furnaces and others. The most important units for the construction of these are being put into operation at Krimatorsk and in the Urals.

In non-ferrous metallurgy big results have been achieved in the mechanisation of mining. Hand-drilling is already a thing of the past. Drilling operations have been mechanised to the extent of 100%. Pneumatic equipment now being manufactured in Soviet plants are used in the Soviet non-ferrous ore mines. This equipment is being manufactured at the Nevinsk Works. It is of interest also to note that between 70% and 80% of the cranes now in use are of the new type.

Methods of enriching ore have been drastically changed. By the selected flotation method now in use the percentage of pure ore has been raised from between 50% and 60% to from 80% to 92%. The construction of eight concentrating plants has been completed ; these have already been put into operation. Another series of concentrating plants are in course of construction and will be put into operation this year.

In regard to light metals, the construction of the Volkhov Aluminium Combine has been completed and is now in operation, with an initial capacity of 5,000 tons and a total capacity of 10,000 tons. The Dniepre Aluminium Combine is almost completed, the initial capacity of which will be 20,000 tons of aluminium per year. In 1931 experimental plants turned out the first batches of magnesium manufactured in the Union. The building has been commenced of a magnesium manufacturing plant with a capacity of 1,000 tons. Methods of obtaining nickel from the Ural ores have been worked out, and the Ural Nickel plant, with an initial capacity of 3,000 tons, is being completed.

During 1933 further advances will be made in the creation of a well-equipped metallurgical industry in the Soviet Union. Ninteen blast-furnaces are to be put into operation, two at Magnitogorsk, two at the Kuznetsk plant, two at Zaporozhe, two at Azovstal, one at the Krivoi Rog plant, one at Lipetsk, while in the existing southern plants a further five blast-furnaces will be installed.

This year there are also being started 51 open-hearth furnaces, 15 electric furnaces, four blooming mills, 15 rolling mills, and four mills for the manufacture of pipes.

This increase in capacity has made it possible to fix the output of pig iron for 1933 at 9 million tons, of steel at 8·9 million tons, and rolled stock at 6·2 million tons.

The following enterprises in the non-ferrous metal

(*Continued on page* 20A.)

Cement for Furnace Settings.

For many types of metallurgical as well as steam-boiler settings, including the laying of firebricks, the protection of the working face of firebrick walls, and the pointing-up of cracks and worn surfaces, of considerable interest is "Sairset" high-temperature air-setting cement. This has a high alumina content, because of the use of Diaspore as a base, which is a mono-hydrate of alumina having a fusion temperature in the neighbourhood of 3,440–3,500° F., being also an extremely hard product, with a specific gravity of 3·4. Incidentally, it may be stated the name Diaspore is derived from the Greek (meaning "to scatter") because of the violent decrepitation that results on heating the material with a blowpipe. Sairset cement is applied after mixing with water in the proportions normally of, say, six parts to one part water by volume, and setting takes place at room temperature, approximately 70° F., while the action of the heat is to sinter to a smooth protective material having a high glaze.

The fusion point of the cement is higher than ordinary cements made from flint fireclays, with practically the same physical and chemical properties as best firebrick, while in addition the product is almost neutral to expansion and contraction, and resistant to temperatures as high as 3,000° F. The good qualities of the cement, which is manufactured in Great Britain for Steam Plant Accessories, Ltd., of London, are due largely to scientific control in all stages of production, the raw material being carefully selected, tested, and blended under laboratory supervision.

In surfacing combustion-chamber brickwork, new or old, two or three coatings are recommended, giving a total thickness of between $\frac{1}{16}$ in.–$\frac{3}{32}$ in. These can be applied either with a brush or by cement gun, and approximately five hours are required to thoroughly mature the first coating, subsequent applications requiring a somewhat shorter period in which to dry out.

When employed for bonding, the cement after burning has a transverse breaking strength of well over 1,000 lb. per sq. in., forming an efficient dense hard joint which offers strong resistance to the destructive effects of slagging.

Fifteen Years of Soviet Industry

(*Continued from page* 134).

industry are to be put into operation in 1933: the Dniepre Aluminium Combine, the Nickel Combine, Kraspolimetal, for lead production, two plants for electrolytic-zinc manufacture, one in Ordzhonikidze and the other at Cheliabinsk; concentrating plants at the Krasnoural Combine, at Kalata, and elsewhere. These will make it possible to increase the production of non-ferrous metals.

In view of certain criticisms which have been directed against this rapid progress, the following figures of costs of production, taken at random from different factories, as examples, are of particular interest. One tractor, in the Stalingrad Factory, cost in 1930, 7,179 roubles; in 1931, 4,076 roubles; while by 1932 it had been reduced to 3,314 roubles. This is a reduction of 53·8%, and it must be remembered was associated with a constant improvement in the quality of production. The motor-lorry at the AMO Factory (AMO 3) cost in 1931, 11,078 roubles; while in 1932 this had been reduced to 5,665 roubles. This is a reduction of 48·9% in cost again with improved quality of production. An agricultural combine from the factory, "Communar," in the Ukraine, cost in 1929-1930, 11,305 roubles; 1931, 4,578 roubles; 1932, 3,800 roubles. This is a reduction of 64·9%.

These figures indicate to what extent Soviet industry, in spite of many difficulties, has been developed during the last 15 years, and in particular reveal the achievements of the Five Year Plan.

MARKET PRICES

ALUMINIUM.

98/99% Purity		£95 0 0

ANTIMONY.

English	£37 0 0 to	£42 10 0
Chinese		27 15 0
Crude		19 10 0

BRASS.

Solid Drawn Tubes	lb.	8¾d.
Brazed Tubes	„	10¾d.
Rods Drawn	„	7¾d.
Wire	„	7¼d.
*Extruded Brass Bars	„	3⅞d.

COPPER.

Standard Cash		£29 2 0
Electrolytic		33 0 0
Best Selected		31 0 0
Tough		30 10 0
Sheets		61 0 0
Wire Bars		33 0 0
Ingot Bars		33 0 0
Solid Drawn Tubes	lb.	9½d.
Brazed Tubes	„	9½d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 1 10½
‡Ferro Tungsten	„	0 1 7½
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL: 2-4% Carbon, scale 12/- per unit	ton	34 2 6
NOMINAL: 4-6% Carbon, scale 7/6 per unit	„	24 10 0
NOMINAL: 6-8% Carbon, scale 7/6 per unit	„	22 17 6
NOMINAL: 8-10% Carbon, scale 7/3 per unit	„	22 12 6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	35 5 0
Guar. max. 1% Carbon, scale 13/6 per unit	„	39 0 0
§Guar. max. 0.7% Carbon, scale 15/- per unit	„	42 17 6
‡Manganese Metal 96-98% Mn.	lb.	0 1 4
‡Metallic Chromium	„	0 2 8
§ Ferro-Vanadium 25-50%	„	0 12 8
§ Spiegel, 18-20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	5 17 6
20/30% basis 25%, scale 3/6 per unit	„	8 10 0
45/50% basis 45%, scale 5/- per unit	„	13 15 0
70/80% basis 75%, scale 7/- per unit	„	19 0 0
90/95% basis 90%, scale 10/- per unit	„	30 0 0
§Silico Manganese 65/75% Mn., basis 65% Mn.	„	14 17 6
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 6
Ferro Phosphorus, 20-25%	ton	17 17 6

FUELS.

Foundry Coke—		
S. Wales	£1 0 0 to	1 2 6
Scotland	—	1 10 0
Durham	1 1 0 to	1 5 0
Furnace Coke—		
Scotland	—	1 7 6
S. Wales	0 16 0 to	0 16 6
Durham	0 13 6 to	0 13 9

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)		£47 0 0
*Commercial Ingots		37 10 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0 0 8
*Cored Bars	„	0 0 10

LEAD.

Soft Foreign		£10 8 9
English		12 0 0

MANUFACTURED IRON.

Scotland—		
Crown Bars, Best		£10 5 0
N.E. Coast—		
Rivets		11 0 0
Best Bars		10 10 0
Common Bars		10 0 0
Lancashire—		
Crown Bars		9 15 0
Hoops	£10 10 0 to	12 0 0
Midlands—		
Crown Bars	£9 15 0 to	10 0 0
Marked Bars		12 0 0
Unmarked Bars		—
Nut and Bolt Bars	£8 7 6 to	8 12 6
Gas Strip		10 12 6
S. Yorks.—		
Best Bars		10 10 0
Hoops..Hcops	£10 10 0 to	12 0 0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	8d.
*Cored Bars	„	10d
†Strip	„	10¼d.
†Sheet to 10 W.G.	„	10½d.
†Wire	„	11¼d.
†Rods	„	10½d.
†Tubes	„	1/3½
†Castings	„	1/1¼

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—	
Hematite M/Nos.	£3 6 0
Foundry No. 1	3 10 0
„ No. 3	3 7 6
N.E. Coast—	
Hematite No. 1	3 0 0
Foundry No. 1	3 1 0
„ No. 3	2 18 6
„ No. 4	2 17 6
Cleveland—	
Foundry No. 3	2 18 6
„ No. 4	2 17 6
Silicon Iron	3 1 0
Forge No. 4	2 17 0
Midlands—	
N. Staffs Forge No. 4	3 1 0
„ Foundry No. 3	3 6 0
Northants—	
Forge No. 4	2 17 6
Foundry No. 3	3 2 6
Derbyshire Forge	3 1 0
„ Foundry No. 3	3 6 0
West Coast Hematite	3 6 0
East „ „ No. 1	3 0 0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 18-16 to £1 approximately.

Pig Iron	Kr. 92	—
Billets	Kr. 280-290	£15 10 0-£16 0 0
Wire Rods	Kr. 265-320	£14 12 6-£17 12 6
Rolled Bars (dead soft)	Kr. 185-210	£10 4 0-£11 11 0
Rolled Charcoal Iron Bars	Kr. 290	£16 0 0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£21 0 0
„ Braziery	19 0 0
„ Wire	—
Brass	16 0 0
Gun Metal	18 0 0
Zinc	8 10 0
Aluminium Cuttings	74 0 0
Lead	9 0 0
Heavy Steel—	
S. Wales	2 0 0
Scotland	1 17 6
Cleveland	2 0 0
Cast Iron—	
Midlands	1 16 0
S. Wales	2 2 0
Cleveland	2 1 0
Steel Turnings—	
Cleveland	1 12 6
Midlands	1 0 6
Cast Iron Borings—	
Cleveland	1 3 6
Scotland	1 12 0

SPELTER.

G.O.B. Official	—
Hard	£12 0 0
English	14 17 0
India	13 15 0
Re-melted	13 15 0

STEEL.

Ship, Bridge, and Tank Plates—		
Scotland		£8 15 0
North-East Coast		8 15 0
Midlands		8 17 6
Boiler Plates (Land), Scotland		9 0 0
„ „ (Marine) „		—
„ „ (Land), N.E. Coast		10 0 0
„ „ (Marine) „		10 10 0
Angles, Scotland		8 7 6
„ North-East Coast		8 7 6
„ Midlands		8 7 6
Joists		8 15 0
Heavy Rails		8 10 0
Fishplates		12 0 0
Light Rails	£8 10 0 to	8 15 0
Sheffield—		
Siemens Acid Billets		9 2 6
Hard Basic	£8 2 6 and	8 12 6
Medium Basic	£6 12 6 and	7 2 6
Soft Basic		6 0 0
Hoops	£9 10 0 to	9 15 0
Manchester—		
Hoops	£9 0 0 to	10 0 0
Scotland, Sheets 24 B.G.		10 5 0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten.	lb.	2/-
Finished Bars 18% Tungsten.	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to 3/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£149 12 0
English	150 15 0
Australian	152 12 6
Eastern	153 10 0
Tin Plates I.C. 20 × 14 box	0 16 0
Block Tin (Cash)	148 15 0

ZINC.

English Sheets	£24 0 0
Rods	26 0 0
Battery Plates	—

* McKechnie Brothers, Ltd., quoted Feb. 8. † C. Clifford & Son, Ltd., quoted Feb. 8. ‡ Murex Limited, quoted Feb. 8.
Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.
§ Prices quoted Feb. 8, ex warehouse.